Sciences of Europe

No 191 (2026)

Sciences of Europe
(Praha, Czech Republic)

ISSN 3162-2364
The journal is registered and published in Czech Republic.
Articles in all spheres of sciences are published in the journal.

Journal is published in Czech, English, Polish, Russian, Chinese, German and French, Ukrainian.
Articles are accepted each month.
Frequency: 24 issues per year.
Format - A4
All articles are reviewed
Free access to the electronic version of journal

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«Sciences of Europe» -
Editorial office: Křižíkova 384/101 Karlín, 186 00 Praha

E-mail: info@european-science.org
Web: www.european-science.org

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ECONOMIC SCIENCES

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Тустикбаев М.
магистрант образовательной программы «Деловое администрирование для руководителей», НАО «Университет Нархоз», г. Алматы
Ибраева Э.А.
доктор исторических наук, DBA, ассоциированный профессор, Школа экономики и менеджмента, НАО «Университет Нархоз», г. Алматы

IMPROVING THE PERSONNEL TRAINING AND DEVELOPMENT SYSTEM IN A CONSTRUCTION COMPANY: EVIDENCE FROM SPECIAL STROY LLP

Tustikbayev M.
master's student, educational program "Business Administration for Executives", Narxoz University, Almaty
Ibrayeva E.
Doctor of Science, DBA, associate professor, School of Economics and Management, Narxoz University, Almaty
DOI: 10.5281/zenodo.21069582

АННОТАЦИЯ

В статье рассматривается совершенствование системы обучения и развития персонала в строительной компании. На основе кейс-анализа ТОО «Special Stroy», анкетирования сотрудников и расчета ROI выявлено, что действующее обучение полезно для текущей работы, но остается фрагментарным и слабо связано с карьерным ростом. Предложена модель, включающая адаптацию, наставничество, профессиональное и управленческое обучение, цифровую базу знаний и оценку через KPI. Научная новизна состоит в компетентностно-экономическом подходе, где обучение персонала рассматривается как инструмент снижения проектных потерь и повышения эффективности компании.

ABSTRACT

The article examines the improvement of personnel training and development in a construction company. Based on the case of Special Stroy LLP, employee survey data and ROI modelling, it is shown that the current training practice is useful for daily work, but fragmented and weakly connected with career growth. The scientific novelty is a competence-ROI approach linking adaptation, mentoring, professional training and a digital knowledge base with project indicators: rework, adaptation period, productivity and turnover.

Ключевые слова: обучение персонала, развитие персонала, наставничество, ROI, строительная компания, человеческий капитал.

Keywords: personnel training, personnel development, mentoring, ROI, construction company, human capital.

Введение

В современных условиях человеческий капитал является стратегическим ресурсом организации: от компетенций сотрудников зависят качество работ, производительность, адаптивность и конкурентоспособность [1]. В строительной сфере обучение особенно значимо, поскольку ошибки персонала напрямую отражаются на сроках проектов, затратах на переделки, безопасности и взаимодействии с подрядчиками.

Актуальность статьи обусловлена тем, что в ТОО «Special Stroy» обучение присутствует, но строится преимущественно как практическая передача опыта на объекте. Такая модель решает текущие задачи, однако не обеспечивает системного накопления компетенций и оценки результатов. Цель исследования - обосновать модель, соединяющую компетентностный подход с измерением экономического эффекта. Гипотеза: формализация обучения через наставничество, цифровую базу знаний и KPI/ROI повышает эффективность строительных проектов.

Методы исследования

Использованы анализ научной литературы, кейс-анализ, сравнительный анализ, обобщение данных анкетирования и экономическое моделирование. Теоретической основой выступили стратегический HR-подход, модель оценки обучения Д. Киркпатрика и ROI-подход Дж. Филлипса [2; 3]. Эмпирическая база - данные магистерского проекта по ТОО «Special Stroy»: формы обучения, результаты опроса, целевые KPI и расчет ожидаемого эффекта.

Результаты

Анализ показал, что наиболее формализованным направлением является обучение по охране труда и технике безопасности. Производственные навыки развиваются через практику, наставничество и работу на объектах. Управленческие и цифровые компетенции развиты

слабее, а оценка эффективности обучения не проводится системно.

Опрос сотрудников выявил противоречие: практическую применимость обучения высоко оценили 69% респондентов, полезность для текущей работы - 62%. Однако системность обучения низко оценили 48%, связь с профессиональным ростом - 49%, современность содержания - 41%. Следовательно, проблема состоит не в отсутствии обучения, а в отсутствии управляемого цикла развития компетенций.

Таблица 1

Ключевые показатели совершенствования системы обучения

Показатель	Текущее состояние	Проблема	Целевой ориентир
Системность обучения	18% высоких оценок	нет единого цикла	план и KPI
Связь с ростом	49% низких оценок	нет карьерной логики	кадровый резерв
Цифровая база	0%	опыт не закреплен	75% пользователей
Срок адаптации	3 месяца	потери при входе	1,5 месяца
Доля переделок	2,0%	затраты качества	1,2%

Примечание. Составлено автором на основе проведенного анализа.

Предложенная модель включает адаптацию новых сотрудников, развитие производственного и инженерно-технического персонала, управленческое обучение, наставничество, цифровую базу знаний и кадровый резерв. Каждый блок связан с измеримым результатом: сроком адаптации, долей переделок, производительностью, проектными сроками и текучестью.

Экономическая оценка показала, что затраты на внедрение системы составляют 3 250 000 тенге. Ожидаемый годовой экономический эффект равен 18 210 000 тенге, чистый эффект - 14 960 000 тенге, ROI - 460,3%, срок окупаемости - 2,1 месяца. Наибольший вклад в эффект дают снижение затрат на переделки и повышение производительности труда. Это подтверждает инвестиционную целесообразность обучения персонала [4].

Обсуждение

Полученные результаты показывают, что для строительной компании обучение должно выполнять функцию управления проектными рисками. Устная передача опыта сохраняет зависимость от отдельных сотрудников, тогда как регламенты, чек-листы, наставничество и цифровая база знаний превращают опыт в организационный капитал.

Научная новизна состоит в компетентностно-экономическом подходе: обучение оценивается одновременно по развитию компетенций и по влиянию на экономику проекта. Это дополняет традиционные модели оценки, поскольку связывает знания и поведение работников с производственными метриками: переделками, адаптацией, производительностью и текучестью.

Заключение

Исследование подтвердило, что действующая система обучения в ТОО «Special Stroy» практически полезна, но требует перехода к системной модели развития персонала. Главные ограничения - фрагментарность, отсутствие цифровой базы знаний, слабая связь с карьерным ростом и недостаточная оценка результатов. Предложенная модель устраняет эти ограничения через адаптацию, наставничество, профессиональное и управленческое обучение, кадровый резерв и KPI/ROI.

Главный академический вывод: обучение персонала в строительной организации следует рассматривать как проектный механизм снижения потерь, а не как отдельное кадровое мероприятие. В этом случае инвестиции в сотрудников становятся источником измеримого экономического эффекта и конкурентного преимущества.

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THE ARMENIAN MORTGAGE TAX REFUND PROGRAM: MARKET DISTORTIONS, FISCAL RISKS AND PHASE-OUT CONSEQUENCES

Parsyan S.,
PhD in Economics, Associate Professor at Armenian State University of Economics, the Republic of Armenia
https://orcid.org/0000-0003-0561-3052
Simonyan A.,
PhD in Economics, Associate Professor at Armenian State University of Economics, the Republic of Armenia
https://orcid.org/0009-0004-2323-1343
Kalantaryan A.,
PhD in Economics, Associate Professor at Armenian State University of Economics, the Republic of Armenia
https://orcid.org/0009-0002-7025-8691
Tumasyan Z.,
PhD in Economics, Associate Professor at Armenian State University of Economics, the Republic of Armenia
https://orcid.org/0009-0000-5322-1497
Gabrielyan H.,
PhD in Economics, Associate Professor at Armenian State University of Economics, the Republic of Armenia
https://orcid.org/0009-0003-4941-5944
DOI: 10.5281/zenodo.21095081

ABSTRACT

This scientific article examines the mortgage income tax refund program implemented in the Republic of Armenia between 2018 and 2026, analyzing its effectiveness as a fiscal instrument for stimulating the real estate market and the systemic risks arising from its gradual phase-out. Based on official data from the Central Bank of Armenia, the State Revenue Committee, and the Cadastre Committee, the study reveals that the mortgage portfolio grew approximately eightfold during the observation period, from AMD 207.4 billion**(1USD=370 AMD)** in January 2018 to AMD 1,670.1 billion in January 2026. Budgetary expenditures for the program increased nearly fivefold, reaching AMD 65-80 billion annually by 2024-2025, while the average monthly refund per beneficiary rose from AMD 97,900 to AMD 147,500. The analysis demonstrates that the program created significant market distortions, including an 11-fold increase in primary market transactions, the marginalization of the secondary market, and the formation of a "price bubble" characterized by price rigidity despite declining transaction volumes following the phase-out in central administrative districts. A simulation of a typical borrower reveals that the termination of the subsidy increases the effective monthly financial burden from AMD 54,500 to AMD 464,500—an 8.5-fold increase—rendering the majority of potential borrowers unable to qualify for mortgages under market conditions. The findings confirm the hypothesis that the program generated a high-dependency market model, and its termination will produce systemic shocks, including an anticipated 30-40 percent decline in new construction projects and rising non-performing loans in peripheral districts.

Keywords: mortgage lending, real estate market, fiscal stability, non-performing loans, Armenia, housing affordability, market distortion.

Introduction

In modern economic conditions, mortgage lending constitutes one of the primary drivers of housing provision and economic activity in the Republic of Armenia. Between 2018 and 2026, the Armenian government implemented a mortgage interest income tax refund program that allowed borrowers to recover significant portions of their income tax payments allocated to loan servicing. The Armenian real estate market was valued at USD 880.4 million in 2018, with expectations of reaching USD 1,249.3 million by 2026 at an annual growth rate of 4.3 percent [1]. However, effective January 1, 2025, the government introduced fundamental changes to the program, including a cap of AMD 750,000 per quarter on income tax refunds for borrowers and co-borrowers, along with a phased elimination mechanism designed to avoid sharp market shocks [2, 3]. Market participants and analysts have reported declining activity in the real estate sector as a consequence of these changes [4]. By early 2026, the market volume reached USD 1.25 billion, with transaction volumes setting historical records [5]; nevertheless, analysts noted reduced market activity attributable to the tax refund program modifications, while residential real estate prices continued to rise by 5.5 percent compared to the previous year [6]. The Chairman of the Central Bank of Armenia stated that no additional risks were perceived in the market, while acknowledging the possibility of declining activity [7]. This article provides a comprehensive analysis of the program's effectiveness and evaluates the impact of its termination on market participants and Armenia's economic stability.

Analysis

The analysis of mortgage loans provided to residents by Armenian commercial banks demonstrates that the sector entered an unprecedented growth phase during the 2018-2025 period. Whereas the mortgage

market had previously developed at moderate rates primarily dependent on real income growth of the population, the eightfold increase recorded in recent years indicates the formation of a new market conjuncture [26]. From January 2018 (AMD 207.4 billion) to January 2026 (AMD 1,670.1 billion), the mortgage portfolio grew approximately eightfold. During 2018-2020, the portfolio grew steadily at an annual average of AMD 100-120 billion. Between 2021 and 2024, growth rates accelerated significantly; during 2024 alone, the portfolio grew by approximately AMD 391 billion (from AMD 1,079.9 billion to AMD 1,471.2 billion).

Table 1

Mortgage Portfolio Growth Dynamics (AMD billion, January of each year)

Year	Portfolio Volume (AMD billion)	Absolute Annual Growth (AMD billion)	Growth Rate (%)
2018	207.4	—	—
2020	363.4	+156.0	75.2 (2 years)
2022	664.4	+301.0	82.8 (2 years)
2024	1,079.9	+415.5	62.5 (2 years)
2026	1,670.1	+590.2	54.6 (2 years)

Source: Central Bank of Armenia [26], author's calculations

A notable pattern emerges from the monthly data: each December registers a sharp jump in lending volumes compared to preceding months. For example, in November 2024, the increase was approximately AMD 26 billion, while in December 2024, it reached AMD 104 billion. This phenomenon is explained by expectations of the phased termination of the income tax refund program, as citizens sought to conclude transactions before year-end to preserve their eligibility for the benefit. This exponential portfolio growth indicates that the Armenian banking system's credit market has become hypersensitive to changes in tax benefits and fiscal policy. A significant portion of banking system assets is concentrated in mortgage loans, and if borrower solvency declines following the termination of the income tax refund, systemic risks may emerge.

Comparing data from the Central Bank and the State Revenue Committee reveals several key trends. Over the past five years, the volume of income tax refunds from the state budget increased more than fourfold (from AMD 13.3 billion in 2020 to AMD 52 billion in 2023). During the same period, the total mortgage portfolio grew threefold (from AMD 363.4 billion to AMD 1,070.8 billion). This dynamic demonstrates that state support served as the primary "fuel" for market growth. Moreover, the more rapid growth of budget expenditures indicates that higher-income borrowers—whose refundable tax amounts per loan are larger—entered the market.

The number of program beneficiaries increased from approximately 4,000 persons in 2018 to over 39,000 by the end of 2024, representing nearly a tenfold increase over seven years. Between 2021 and 2023, a sharp jump in beneficiary numbers was recorded (annual average of 8,000 new beneficiaries), driven by low interest rates and rumors of the benefit's termination in Yerevan. The average annual refund per borrower increased from AMD 1,175,000 in 2018 to a projected AMD 1,770,000 in 2025, with the average monthly refund rising from AMD 97,900 to AMD 147,500. The average monthly refund of AMD 132,000 (2024) constitutes approximately 50 percent of the average monthly salary in Armenia, meaning the state provides a subsidy equivalent to "half a salary" to each beneficiary on a monthly basis. Since the refund amount is growing faster than the number of beneficiaries (14-fold versus 10-fold), this creates fiscal instability, where the state cannot maintain long-term balance between revenues and expenditures without jeopardizing its ability to meet financial obligations.

The income tax refund program has had a decisive impact on the structure of Armenia's real estate market, sharply increasing the share of the primary market. Before 2018, the secondary market (existing housing stock) dominated, accounting for more than 80 percent of transactions. However, starting from 2019, a sharp demand shift occurred: the number of primary market transactions increased approximately 11-fold, from 1,200 in 2018 to a projected 13,500 in 2024, while the secondary market exhibited stagnation and decline trends. The exponential growth of the primary market curve directly correlates with the increase in income tax refund volumes from the state budget, demonstrating that the overwhelming majority—more than 90 percent—of primary market transactions were conducted exclusively through the tax benefit. Without this benefit, the price of newly constructed housing and the loan servicing burden would exceed the solvency limits of the average borrower. The decline in secondary market transactions indicates that the old housing stock has lost its investment attractiveness; financial resources have been "sucked into" the primary market, leading to artificial overvaluation of new construction prices, while the secondary market faces a liquidity shortage.

The phased limitation of the income tax refund program aimed to decentralize the construction boom

from Yerevan's small center. In the Central and Arabkir districts, which were the first to experience restrictions, critical changes were observed. In the 3-6 months before the restrictions took effect, both districts recorded unprecedented increases in transactions as borrowers rushed to conclude mortgage agreements, leading to oversaturation of the primary market. Following the elimination of the benefit, sales rates for new constructions in the Central and Arabkir districts decreased by approximately 30-45 percent. Citizens, deprived of 40-50 percent monthly payment subsidies, ceased to consider these districts as affordable housing options. Analysis shows that demand did not disappear but rather "leaked" to adjacent districts where the benefit remained in effect: from Central to Malatia-Sebastia and Shengavit; from Arabkir to Kanaker-Zeytun and Davtashen. This led to peripheral districts' price growth rates exceeding those of the center in 2023-2024.

Contrary to expectations that demand decline would be followed by price decreases, prices in the Central and Arabkir districts were maintained or grew at slow rates. This is explained by two factors: (1) the luxury segment—a portion of buyers in the center were not dependent on the income tax refund (wealthy individuals, diaspora Armenians); and (2) developer strategy—developers, possessing sufficient financial reserves, did not make significant price concessions, preferring to wait or offer internal installment payment schemes. The example of Central and Arabkir districts confirms the forecast that after 2025, when the benefit is eliminated throughout Yerevan, the sharp demand decline will extend across the entire city. Since borrowers in peripheral districts are more dependent on the tax refund than those in the center, the market "freeze" after 2025 will be more severe.

To demonstrate the impact of benefit termination on a typical borrower, consider the following market conditions in Yerevan for 2024-2025: property value AMD 50,000,000, down payment 10 percent (AMD 5,000,000), loan amount AMD 45,000,000, annual interest rate 11 percent (average for Armenian banks), loan term 20 years (240 months), with annuity repayment scheme. Using the annuity formula $A = P \times [r(1+r)^n] / [(1+r)^n - 1]$ (where P = 45 million, r = 0.11/12, n = 240), the monthly payment to the bank is AMD 464,500, and the average monthly interest payment in the first year is approximately AMD 410,000.

Table 2

Effective Monthly Borrowers' Expenditure Before and After Benefit Termination

Indicator	**With Benefit**	**After Benefit Termination**	**Change**
Monthly payment to bank	AMD 464,500	AMD 464,500	0
Income tax refund	-AMD 410,000	AMD 0	-AMD 410,000
Effective monthly expenditure	AMD 54,500	AMD 464,500	+AMD 410,000

Source: Author's calculations based on market data

This calculation reveals a crisis scenario: the borrower's effective monthly financial burden increases 8.5 times, from AMD 54,500 to AMD 464,500. The income tax refund mechanism created an illusion of "cheap money" for the borrower, masking the true volume of mortgage obligations. Whereas the net monthly expenditure of AMD 55,000 could previously be afforded by a person earning even below-average wages, the situation changes radically after benefit termination. To make a AMD 464,500 monthly payment, the borrower must have net monthly income of at least AMD 800,000-900,000, considering banks' income/expense ratio requirements (usually not exceeding 40-50 percent of total income). Given the current structure of Armenia's labor market and the average monthly wage level, the overwhelming majority of borrowers do not have such high incomes. Consequently, benefit termination automatically excludes 70-80 percent of potential buyers from the market—the segment that served as the primary driving force of the primary market will no longer qualify as creditworthy subjects under standard market conditions.

Based on the "demand shock" and "inertial supply" interaction, new construction starts in Yerevan for 2025-2026 are forecast to decline by 30-40 percent. Developers have adopted a cautious strategy, slowing the acquisition of new land plots and project design. The primary reason is the liquidity gap: without the income tax refund benefit, the marketability of housing in the primary market sharply decreases. Without rapid presales—which previously served as an interest-free financing source for construction—developers will be forced to rely more on bank loans. Under high interest rate conditions, this raises construction costs and risk levels, leading many to freeze their projects. Construction capital, seeking higher profitability and state support, has begun "fleeing" from Yerevan to the provinces (Kotayk, Ararat, Armavir), where the benefit remains in effect. This shift leads to the concentration of construction activity at Yerevan's city limits and adjacent communities, creating new challenges.

Regarding non-performing loans (NPLs), despite expectations that benefit termination in Central and Arabkir districts would lead to mass defaults, no sharp or catastrophic increase has been recorded as of early 2025. NPL share in these districts ranges between 1.5 and 2.2 percent—slightly above the system average but still manageable. Borrowers in these districts are primarily high-income individuals with financial buffers who can service loans even without tax refunds. However, there is an increase in "watch" class loans (delays of less than 90 days). Borrowers who took loans "at the

margin," where the income tax refund constituted 40-50 percent of their monthly payment, now face difficulties. Because property prices in the center are high, borrowers cannot easily refinance or sell without losses, creating an accumulation of "stagnant" debt. Real NPL growth is expected not in the center but in peripheral administrative districts (Malatia, Shengavit, Ajapnyak) when the benefit ceases there as well. In these areas, borrower incomes are lower, and an increase of AMD 100,000-150,000 in the monthly payment could be critical. If demand decreases in the periphery and prices begin to decline, borrowers will find themselves in a "negative equity" zone (where the loan balance exceeds the property's market value)—the most dangerous precondition for NPL growth.

Conclusion

The multi-layered analysis conducted within this study allows for the formulation of scientifically grounded conclusions regarding the mortgage income tax refund program's impact on the Armenian real estate market. The research confirms that this program constituted one of the most influential yet simultaneously most risky fiscal instruments of the past decade in Armenia's economy. Its effect can be characterized as a "double-edged sword": stimulating unprecedented growth in the construction sector while creating serious macroeconomic imbalances.

The hypothesis that the unprecedented market activity was artificially stimulated and falls outside the standard framework of economic regularities is confirmed. The eightfold growth of the mortgage portfolio between 2018 and 2025, bringing the portfolio volume close to the AMD 1.5 trillion threshold, is directly and strongly correlated with state budget tax expenditures. Without large-scale state subsidization, the mortgage market—under its current price offerings and volumes—simply cannot be self-sufficient and viable. The program transformed over time into a more "expensive" burden for the state budget, not only due to the increasing number of beneficiaries but also because of the continuous increase in the benefit amount per beneficiary. The state found itself in a "fiscal trap" where every increase in property prices automatically increases the budget's expenditure burden.

The study documents the absolute and indisputable dominance of the primary market, expressed in more than an 11-fold increase in transaction volumes, definitively confirming that the tax benefit became the main factor segmenting and deforming the market. The secondary market has been practically pushed out of competition, lacking similar state support. New construction prices have diverged from market logic and the population's normal solvency level, based exclusively on subsidized demand.

Contrary to optimistic hypotheses that tax benefit elimination would lead to rapid and proportional price decreases, the analysis reveals the phenomenon of "price rigidity." Developers have adopted a price maintenance strategy, and demand has simply shifted to Yerevan's suburbs. This finding is significant because it demonstrates that the market possesses high inertial force. Prices do not flexibly follow sharp demand changes, creating a "stagnation" risk that could lead to a situation where transaction volumes decrease to critical levels while prices remain high, creating an illusion of stability beneath which serious liquidity problems are hidden. The experience of Central and Arabkir districts shows that administrative or tax restrictions alone are insufficient to correct pricing policy as long as deep-seated imbalances and "artificially high" expectations exist in the market.

The scientific novelty of this work lies in its systematic multi-factor scenario modeling of the "typical borrower's financial shock" in the context of expected legislative restrictions. The discovered 8.5-fold increase in financial burden scientifically substantiates that a significant portion of borrowers may face a "solvency gap" if their incomes do not grow proportionally. These findings have practical value for the Armenian government and State Revenue Committee as a basis for macroeconomic planning and GDP growth rate adjustments; for commercial banks regarding NPL risk management and stress testing implementation; and for developers in revising project pricing policies and orienting toward regional markets where state support still exists. The main hypothesis—that the income tax refund program created a high-dependency market model whose termination will produce systemic shocks—is fully confirmed.

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TAXATION OF LABOR AND CAPITAL INCOME IN TURKEY AND AZERBAIJAN: A COMPARATIVE STUDY ON THE TAX BURDEN

Jafarova R.
Türkiye, Anadolu University
ORCID: 0009-0008-3233-1222
Erkan Üyümez M.
Prof. Dr.
Türkiye, Anadolu University
ORCID: 0000-0001-7567-3486
DOI: 10.5281/zenodo.21095119

ABSTRACT

The aim of this study is to comparatively examine the tax burden on labor and capital income in Turkey and Azerbaijan and to reveal the key trends in this area. Within the scope of labor income, wage earners are particularly considered. The primary reason for this is that wage incomes are largely taxed through source-based withholding, and the tax burden is concentrated directly and regularly on this segment of the population.

Capital income, on the other hand, refers to the earnings individuals derive from their assets, and its taxation structure exhibits a more distinct and flexible framework compared to labor income. These incomes are taxed through various methods, and different rates and mechanisms may apply in practice. This situation makes it difficult to determine the tax burden on capital income in a direct and clear manner.

When evaluated overall, there are structural differences between the taxation of labor and capital income, and these differences directly affect the distribution of the tax burden. The study analyzes the tax burden on labor and capital income in Turkey and Azerbaijan and discusses the findings in comparison with OECD data.

Keywords: tax burden, labor income, capital income, Turkey, Azerbaijan.

1. Introduction

The expansion of public authority's activities in the economic and social spheres naturally entails a greater need for financing. The most important tool for meeting this need is taxes, and the taxation process imposes both financial and perceptual burdens on individuals and institutions. While tax payments reduce taxpayers' disposable income, they also exert a psychological impact due to the sense of obligation.

The concept of tax burden is considered one of the key indicators showing what proportion of income generated in an economy is transferred to the public sector. In this respect, it reveals not only the size of public finance but also how taxation is distributed among different segments of society. The distribution of the tax burden provides an important metric for assessing whether the fiscal system operates fairly. (OECD, 2025; Çevik, 2005). The findings of this study are consistent with D. Pashayeva's view that improving tax administration and tax control mechanisms plays an important role in strengthening the effectiveness of the tax system (D. Pashayeva, 2019). Today, how the tax burden is shared among individuals, sectors, and income groups is increasingly being debated. (Karaş & Hayrullahoğlu, 2023). In this context, the tax burden is directly related to macro objectives such as economic balance, income distribution, and sustainable growth, beyond being merely a financial indicator. It also enables comparisons between different countries and economic structures. When examining the taxation of wage income, significant differences can emerge among various groups due to different practices (Öztürk & Ozansoy, 2011; Giray, 2018). It is observed that the tax burden is not distributed equally, particularly among public and private sector employees or between individuals with different statuses within the public sector. These disparities are among the elements that strengthen discussions regarding the fairness dimension of the tax system.

2. Overview of capital and labor incomes in Turkey and Azerbaijan

The tax-related evaluation of income elements constitutes an important area of study in understanding the functioning of financial systems. In particular, the methods used in taxing earnings derived from labor and capital reflect states' economic priorities and fiscal policy choices. Although these two types of income are covered under the same income tax framework in tax legislation, the methods applied to them often rely on different techniques.

The regular and trackable nature of earnings derived from labor places these incomes within a more standardized tax structure. In contrast, the diversity of capital-derived income leads to the emergence of more flexible and differentiated tax regulations. In particular, special regulations for capital income are frequently employed to encourage investment, increase savings, and support economic growth.

In this context, the differences that emerge in tax systems shape not only collection methods but also the actual distribution of the tax burden across income groups. Demonstrating the tax policy differences between labor and capital is crucial for evaluating the economic and social impacts of countries' tax policies. In this section, the current taxation structure in Turkey and Azerbaijan will be examined separately in terms of labor and capital income.

2.1 Capital and labor incomes in Turkey

Taxes, which constitute the primary source of revenue for public finance, are generally designed taking into account taxpayers' ability to pay. Since income level is the most important indicator of ability to pay, taxes levied on income are at the center of modern tax systems. In this context, income tax includes both earnings derived from labor and returns from capital sources

within its tax base. However, there are certain economic and structural differences between different types of income. Income derived from work is considered "earned income" because it results directly from an individual's labor and effort. In contrast, capital income is regarded as a more passive form of earnings because it arises as a result of past savings or asset ownership. This distinction reinforces the view that the type of income should also be taken into account when measuring solvency. When examining the structure of tax systems, it is observed that there are significant methodological differences between the taxation methods for labor income and capital income. This difference arises not only from tax rates but also from collection timings and implementation mechanisms. While labor income is generally taxed through withholding at source on wages, capital income is subject to a declaration-based system with periodic collection. (Organ & Yavuz, 2017). The system applied to wage incomes constitutes a highly rapid and automated collection mechanism since the tax is deducted before income is received. This situation leads to laborers bearing the tax burden before they receive their income.

In Turkey, the taxation of capital income is addressed within the framework of securities and real estate capital gains under the Income Tax Law (Republic of Turkey, 1961; Nacar &

Karabacak, 2022). Securities income comprises interest on deposits, dividend income, repo earnings, and returns from various financial investment instruments, while real estate income consists of earnings resulting from the rental of immovable properties. The methods applied in taxing these types of income exhibit a more distinct and flexible structure compared to those applied to labor income.

The stop-loss system is predominantly employed in taxing securities income (OECD, 2025). In particular, withholding taxes levied at source on deposit interest and earnings from certain investment instruments facilitate tax collection. However, low-rate withholding taxes applied to certain income elements or specific declaration thresholds may reduce the effective tax burden on capital income. This situation is considered to be a result of fiscal policies aimed at encouraging investment instruments.

Regarding the taxation of real estate capital income, the exemption amounts granted to taxpayers and the possibilities for expense deductions draw attention. In particular, the actual expense and flat-rate expense methods enable the reduction of the taxable base arising from rental income. These practices have a mitigating effect on the effective tax burden faced by real estate owners.

Another noteworthy aspect in the taxation of capital income is that tax planning opportunities for this type of income are broader compared to labor income. The timing of income receipt, the nature of the investment instrument, and options for benefiting from tax advantages provide capital holders with a more flexible course of action. In contrast, the direct and regular withholding of tax at source on labor income greatly limits such flexibility.

Consequently, when the withholding tax practices, exemption regulations, and expense deduction opportunities in the taxation of capital income in Turkey are considered together, it becomes apparent that the tax burden on this type of income is more flexible and relatively manageable compared to labor income. This situation reveals a significant difference in terms of the distribution of the tax burden among different types of income.

2.2. Capital and labor income in Azerbaijan

The Azerbaijani tax system is based on a structure that applies both direct and indirect taxes and covers the incomes of both natural and legal persons. (Republic of Azerbaijan, 2000).

Since the taxation of labor and capital incomes is carried out through different mechanisms within this system, certain disparities arise in the distribution of the tax burden. Labor incomes are primarily subject to taxation under personal income tax, and a progressive tax structure is applied. While lower rates apply up to a certain income level, the tax rate increases as income rises (Akhundzada, 2020). This situation results in an increasing tax burden on labor income with rising income levels.

In Azerbaijan, the taxation of capital income is considered within the general income tax system under the umbrella of income from securities and real estate. Capital income consists of interest income, dividend income, returns from various financial investments, and income derived from the rental of real estate. The taxation structure exhibits a simpler and less differentiated appearance compared to Turkey.

The rates applied in the taxation of capital gains may vary depending on the type of income and relevant regulations. The taxation system applied to interest and dividend income generally has a simpler structure and features limited rate differences among different investment instruments. This situation enables tax practices to be conducted within a more predictable framework.

Regarding real estate capital income, rental income is declared within a specific legal framework and taxed according to general income tax principles. The absence of comprehensive exemption and expense deduction mechanisms as found in Turkey leads to a more direct approach to taxation. However, the system's simple structure enables taxpayers to more easily track their tax obligations.

The key feature that stands out in the taxation of capital income in the Azerbaijani tax system is that tax rates are relatively low and the implementation mechanisms are more integrated (Məmmədov, 2022; Hasanov, 2009). This structure contributes to keeping the overall tax burden on capital income at a more modest level compared to many developed economies. It is also considered an important fiscal policy tool in terms of supporting the investment environment and encouraging capital mobility.

As a result, the taxation of capital income in Azerbaijan presents a more integrated picture compared to Turkey due to its simple rate structure and more limited differentiations. The implemented system keeps the tax burden on capital income relatively low, presenting a more advantageous tax structure compared to labor income in this regard.

3. Tax burden on capital and labor income in Turkey and Azerbaijan

In the previous section, the structural framework regarding the taxation of labor and capital income in the tax systems of Turkey and Azerbaijan was outlined. However, evaluating taxation systems solely based on legal regulations is not sufficient. Examining the actual burden imposed by these regulations on income groups enables a more accurate analysis of the effectiveness and fairness dimensions of tax systems. In this context, the following section will discuss the tax burden on labor and capital income in greater detail for both countries.

3.1 The tax burden on labor income in Turkey

The taxation of labor income in tax systems entails certain limitations both in terms of the method of determining the tax base and the applied tax schedule. The expense items that can be taken into account in the calculation of taxable income for wage income are quite limited in scope. The fact that employees can deduct only limited items from their taxable income, such as mandatory social security deductions, insurance premiums within certain limits, and union dues, leads to the taxation of labor income based on a broad tax base. This situation causes employees to face a higher taxable amount compared to their actual income.

Additionally, their labor income is often subject to a progressive tax rate. As income levels increase, the tax rate also rises, creating a progressively concentrated tax burden, particularly on wage earners. This structure can lead to a more limited than expected increase in net earnings with income growth. In particular, moving into different tax brackets throughout the year can lead to significant reductions in employees' net income.

Another noteworthy aspect in the taxation of labor income is that these incomes are largely taxed at source. Since wages are subject to tax deduction before being paid to employees, tax collection is instantaneous and certain. This ensures high efficiency in terms of tax compliance, but eliminates flexibility for employees. Consequently, when the limited deductions for expenses in the taxation of labor income, the progressive tax structure, and the source-based deduction method are considered together, it can be said that a concentrated and directly felt tax burden arises on this type of income. This structure creates a more pronounced pressure on labor income in terms of the distributional impact of the tax system.

Taxable monthly income	Tax rate
Up to 190,000 TL	15%
For the first 190,000 TL of 400,000 TL, 28,500 TL, and the excess amount	20%
70.500 TL for 400.000 TL of 1.000.000 TL, (in wage income 70,500 TL for 400,000 TL of 1,500,000 TL), the remainder	27%
232.500 TL for 1.000.000 TL of 5.300.000 TL, (in wage income 367,500 TL for 1,500,000 TL of 5,300,000 TL), the remainder	35%
1.737.500 TL for 5.300.000 TL more than 5.300.000 TL, (1.697.500 TL for 5.300.000 TL more than 5.300.000 TL in wage income), surplus	40%

Source: Income Tax Law Art. 103, current tariff for 2026 (Republic of Turkey, 1961).

3.2. Tax burden on capital income in Turkey

In Turkey, the tax burden on capital income varies depending on the type of income obtained, but it is predominantly applied through the withholding (source-based deduction) system.

Dividend income, which is considered a type of capital income, is generally subject to a 10% withholding tax; however, for natural persons, half of the dividend income is exempt from income tax, and the remaining portion must be included in the annual income tax return if it exceeds a certain threshold. This structure both partially reduces double taxation and enables more controlled taxation of investment income.

Regarding interest income, taxation rates vary depending on the type of investment instrument (PwC Worldwide Tax Summaries, 2025). While stopaj rates, which generally range from 5% to 15% depending on the term length for deposit interest, may periodically drop to 0% for certain public debt instruments such as government bonds and Treasury bills. Regarding income earned from investment funds, withholding tax is generally applied at a rate between 0% and 10% depending on the type of fund, and in most cases no separate declaration obligation arises.

Overall, the tax system for capital income in Turkey is relatively low-burden and simple, with withholding tax rates ranging from 0% to 15% and limited reporting obligations. This structure aims to encourage the redirection of savings to financial markets while also increasing the attractiveness of the investment environment.

3.3. Tax burden on labor income in Azerbaijan

Within the Azerbaijani tax system, the taxation of wage income constitutes an important area directly affecting both employees in the labor market and their employers. The tax burden on labor income consists not only of income tax but also of various socially mandated deductions. In this context, wage income is subject to primarily income tax, mandatory social security contributions, unemployment insurance contributions, and mandatory health insurance payments. These deductions are generally calculated by the employer and transferred on behalf of the employee to the relevant

public institutions. This situation results in a large portion of wage income being taxed at source. In recent years, various structural reforms have been implemented in Azerbaijan to reduce the tax burden on labor income (Mammadov, 2022). To specifically encourage the non-oil private sector, reductions in income tax rates and facilitative regulations on certain social security contributions have been implemented. These reforms are linked to the goals of increasing employment and strengthening the formal wage structure. The taxation of wage incomes may vary depending on the sector and income level. While a lower-rate and progressive tax structure is applied in non-oil sectors, some sectors may be subject to more traditional rates. This situation indicates that the tax burden imposed on labor income is not homogeneous. In addition, mandatory contributions to social security and health systems are among the significant factors that increase the overall tax burden on labor income. These deductions are borne by both employers and employees, thus imposing a dual burden on wage costs. Consequently, the taxation of labor income in Azerbaijan is not limited to income tax alone but has a multi-component structure that includes social contributions. Therefore, the total tax burden on wages can vary significantly depending on the structure of the system.

3.4 Personal income tax Rates (Personal income tax)

Taking into account the provisions of Article 101.1-1 of the tax code, the tax on the monthly income of individuals from Hired work is deducted according to the following table. This schedule applies only to those who are taxed on the monthly income of individuals working in the oil and gas sector and taxpayers belonging to the public sector.

Taxable monthly income	**Tax rate**
Up to 2,500 AZN	3%
From 2,500 AZN to 8,000 AZN	10% of the amount between 75 AZN + 2,500 AZN and 8,000 AZN.
Over 2,500 AZN	625 AZN + 14% of the amount exceeding 8,000 AZN.

The tax is deducted from the monthly income of individuals who do not have activities in the oil and gas sector and work in taxpayers belonging to the non-public sector at the following rates.

Taxable monthly income	**Tax rate**
Up to 2,500 AZN	14%
Over 2,500 AZN	350 AZN + 25% of the amount exceeding 2,500 AZN.

Source: Tax Council Of Azerbaijan Republic, 2026

3.5 Tax burden on capital income in Azerbaijan

In Azerbaijan, taxation of capital income is considered within the general income tax system rather than as a separate and independent tax regime. Within this framework, capital income earned by natural persons is generally subject to income tax, with applicable rates typically starting at around 14% and potentially rising to 25% depending on income level and relevant regulations. For legal entities, capital income is considered within corporate earnings and is taxed at the standard corporate tax rate. This rate is generally applied at approximately 20%. This structure demonstrates that instead of a single special regime for the taxation of capital income, an integrated approach within the general tax system is adopted. Overall, the tax burden on capital income in Azerbaijan is structured within a relatively simpler system, with taxation largely occurring at the time of income realization and based on general tax rates (PwC Worldwide Tax Summaries, 2025; Hasanov, 2009).

4. Comparison Comparison of Labor and Capital Income Taxation in Turkey and Azerbaijan

Table 1.

Comparison of Labor and Capital Income Taxation in Turkey and Azerbaijan

Criteria	Turkey (Labor)	Turkey (Capital)	Azerbaijan (Labor)	Azerbaijan (Capital)
Tax type	Income tax + SSI	Income + corporate tax	Income tax + social contributions	Income + corporate tax
Tax rate	15% – 40% (progressive)	5% – 40% (variable)	Non-oil private sector:3%-10%, 14%(progressive) State & oil/gas sector: 14% – 25% (progressive	14%- 25% *(Individuals)* ~20% *(Corporate entities)*
Taxation method	At source (withholding)	Withholding + declaration	At source	General system
Additional charges	SOCSO, unemployment premium	Generally none	Social insurance, health	Limited
Exception/advantage	Limited	Widespread	Limited	Moderate
Exception/advantage	High	Low-Medium	Medium-High	Moderate

Source: Prepared by the author using the Tax Codes of the Republic of Azerbaijan and the Republic of Turkey.

Although the tax systems of Turkey and Azerbaijan possess distinct structural features in terms of taxing labor and capital income, they produce similar results in terms of the resulting tax burden distribution. In both countries, labor income has a more regular, transparent, and source-based taxed structure, while capital income stands out as an area characterized by greater flexibility and taxation through different methods.

In Turkey, labor income faces a high and sustained tax burden due to the progressive tax schedule and mandatory social security deductions. Taxing wages at the source directly increases the efficiency of tax collection but severely limits tax planning opportunities for taxpayers. In contrast, capital income is subject to a more flexible taxation regime through varying taxation methods according to different income types, withholding tax practices, and various exemption arrangements. This situation can often result in the effective tax burden on capital income being below the statutory rates.

In Azerbaijan, the tax system exhibits a simpler and more integrated structure. Labor income is taxed at specific rates, and in addition, social security and health contributions increase the overall burden. Instead of forming a separate tax category, capital income is treated within the general income tax system. This structure offers a simpler and more predictable framework for taxation, but it also results in a more limited set of elements determining the tax burden on capital income.

When both countries are considered together, although the taxation methods differ, the resulting outcome is similar: capital income faces a lower or more manageable tax burden compared to labor income. This situation raises significant debates, particularly regarding the distribution of the tax burden and economic justice. As international studies have shown, the trend towards more favorable taxation of capital income is not unique to these two countries but is considered part of a broader systematic structure.

5. Capital Tax Burden Comparison in Turkey and Azerbaijan within the Framework of OECD Data

The taxation of capital income is carried out at lower rates and generally through a separate system, distinct from the taxation of labor income, in many countries. In OECD countries, these income types (dividends, interest, and other investment returns) are generally treated within the framework of a dual income tax approach, and the average tax burden varies between approximately 15% and 23%. In this context, although capital income enjoys more favorable tax regimes compared to labor income, there are significant differences across countries.

In Turkey, the taxation of capital income is largely carried out through the withholding tax mechanism. Generally, a 10% withholding tax is applied on dividend income, and if the income exceeds a certain threshold, half of the income may be subject to income tax. With regard to interest income, withholding tax rates ranging from 0% to 15% are applied depending on

the type of investment instrument. In certain public debt instruments, such as government bonds, the tax burden may periodically approach zero. This structure causes the effective tax burden on capital income in Turkey to remain at low levels in most cases, with the general range falling around 0%–15%.

In Azerbaijan, the taxation of capital income has a simpler structure. Dividend and interest income is generally subject to withholding taxes of around 5–10%, while capital income is largely treated within a flat-rate income tax system. Compared to Turkey, there are fewer exceptions and a less tiered structure, which results in a simpler system but one that imposes a relatively more uniform tax burden.

When compared to OECD countries, Turkey's tax burden on capital income generally falls at the lower end of the average range, and in some cases, lower effective rates are observed (Organisation for Economic Co-operation and Development, 2025). As for Azerbaijan, it exhibits a structure that is closer to the OECD average but with a more fixed rate.

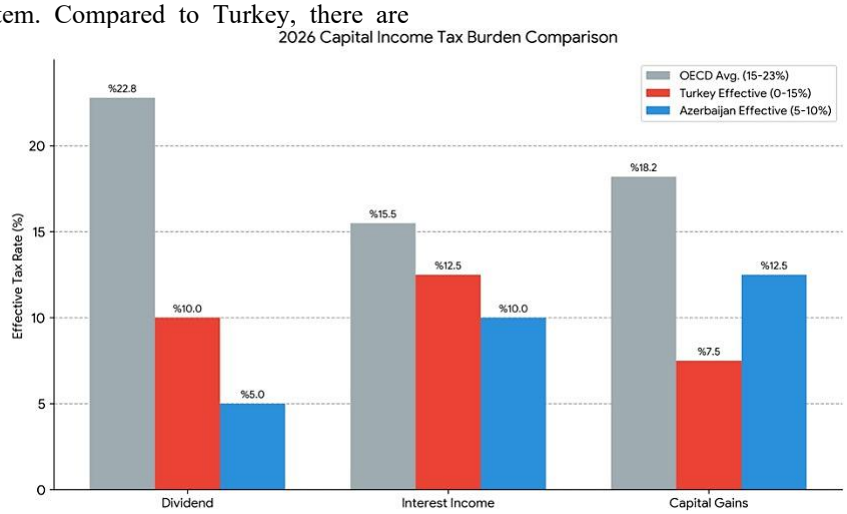

Figure 1. Capital İncometax Burden Comparison
Source: Organisation for Economic Co-operation and Development, 2025

Overall, when evaluated, Turkey implements a low-rate system with a strong emphasis on incentives for capital income and with a focus on withholding taxes, while Azerbaijan adopts a simpler but relatively more standardized taxation approach.

6. Comparison of Labor Tax Burdens in Turkey and Azerbaijan within the Framework of OECD Data

The data from Taxing Wages published by the OECD reveals that the tax wedge, which shows the total tax burden on labor income, exhibits significant differences between countries.

Table 2.

Comparison of total tax wedge, 2025
As % of labour costs

Country[1]	**Total tax wedge 2025 (1)**	**Annual change, 2025/2024 (in percentage points)[2]**			
		Tax wedge (2)	**Income tax (3)**	**Employee SSC (4)**	**Employer SSC[3] (5)**
Belgium	52.5	0.08	-0.02	-0.01	0.11
Germany	49.3	1.34	0.28	0.53	0.52
France	47.2	0.06	0.06	0.00	0.00
Austria	47.1	0.29	-0.01	0.00	0.00
Italy	45.8	-1.21	-1.21	0.00	0.00
Slovenia	45.3	0.63	-0.06	0.32	0.37
Slovak Republic	42.7	0.20	0.20	0.00	0.00
Estonia	42.6	1.95	1.95	0.00	0.00
Finland	42.5	0.35	-0.09	0.09	0.35
Spain	41.4	0.31	0.25	0.00	0.05
Czechia	41.2	0.24	0.24	0.00	0.00
Hungary	41.2	0.00	0.00	0.00	0.00

Country[1]	Total tax wedge 2025 (1)	Annual change, 2025/2024 (in percentage points)[2]			
		Tax wedge (2)	Income tax (3)	Employee SSC (4)	Employer SSC[3] (5)
Sweden	41.1	-0.37	-0.37	0.00	0.00
Türkiye	40.3	0.76	0.29	-0.08	0.55
Luxembourg	40.2	0.24	-0.54	-0.11	0.88
Latvia	40.1	-1.44	-1.44	0.00	0.00
Lithuania	39.8	0.38	0.38	0.00	0.00
Portugal	39.3	-0.24	-0.24	0.00	0.00
Greece	39.3	-0.16	0.54	-0.36	-0.34
Norway	36.4	-0.07	0.02	-0.09	0.00
Netherlands	35.9	0.04	0.23	-0.41	0.22
Denmark	35.8	-0.41	-0.48	0.00	0.06
Poland	35.0	0.28	0.32	0.01	-0.04
Japan	33.1	0.39	0.46	-0.04	-0.04
Ireland	32.6	-0.63	-0.79	0.06	0.10
United Kingdom	32.4	2.45	0.98	-0.31	1.77
Canada	32.1	0.13	-0.38	0.28	0.23
Iceland	31.5	-0.05	-0.04	-0.01	0.00
United States	30.0	-0.09	-0.08	0.00	-0.01
Australia	27.9	-1.67	-1.70	0.00	0.02
Costa Rica	27.7	0.00	0.00	0.00	0.00
Israel	26.1	1.09	0.26	0.43	0.39
Korea	24.8	0.13	0.18	0.00	-0.05
Switzerland	23.0	0.02	0.02	0.00	0.00
Mexico	21.7	0.36	0.37	0.00	-0.01
New Zealand	20.8	0.03	0.03	0.00	0.00
Chile	7.5	0.46	0.11	-0.03	0.37
Colombia	0.0	0.00	0.00	0.00	0.00
OECD Average	**35.1**	**0.15**	**-0.01**	**0.01**	**0.15**

Note: Table shows results for a single individual without children earning the average wage.
Source: OECD, 2025

While the OECD average is approximately 35.1%, this rate in Turkey stands at 40.3%, above the average (OECD, 2025). This situation indicates that the taxation of labor income is relatively heavier in Turkey and that the total fiscal burden on employees and employers is at high levels.

Turkey's position above the OECD average is primarily due to the combined effect of income tax and social security deductions. This structure reduces the net income earned by employees while also increasing labor costs for employers. Therefore, it can be said that the tax burden on labor in Turkey is more pronounced compared to many OECD countries.

Although Azerbaijan is not an OECD member, it has a lower-rate income tax structure and a different social security contribution system, resulting in a more limited overall tax burden on labor income compared to Turkey. In particular, the relatively low income tax rates and the simpler structure of the system contribute to maintaining a more balanced overall burden on labor.

When evaluated overall, OECD data clearly show that labor income in Turkey is subject to a high tax burden, while in Azerbaijan this burden is understood to be lower and more stable. This difference serves as an important indicator for comparing the impact of tax structures and social contribution systems on labor between the two countries.

Result

This study examined the tax systems of Turkey and Azerbaijan in a comparative framework in terms of the relative tax burden on labor and capital income. The findings indicate that both countries exhibit an imbalance in the distribution of the tax burden against labor income.

In Turkey, wage incomes are subject to a regular and systematic tax burden through withholding taxation mechanisms at source, while capital incomes are taxed in a relatively more flexible structure, particularly through time-based exemptions, exclusions, and differentiated taxation practices. This situation reveals that labor bears a higher tax burden compared to capital in terms of effective tax burden.

In the case of Azerbaijan, the fact that capital income is not separated in detail as a separate tax category and is evaluated within the general income tax system indicates a more integrated but less segmented tax structure. Within this structure, it is observed that labor income is taxed in a more regular and visible manner, while capital income is subject to a relatively more limited and indirect taxation regime.

When evaluated overall, it is concluded that both in Turkey and Azerbaijan, labor income is subject to a higher and more sustained tax burden compared to capital income in the tax systems. This finding has significant structural implications in terms of tax justice, income distribution, and the effectiveness of tax policy, and indicates the need to reevaluate the existing tax architecture.

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ЕКОНОМІКА ЗНАНЬ У ТУРИЗМІ: СУТНІСТЬ, СКЛАДОВІ ТА РОЛЬ У КОНКУРЕНТОСПРОМОЖНОСТІ ДЕСТИНАЦІЙ

Писарева І.В.
Харківський національний університет міського господарства імені О.М. Бекетова, Україна, доцент

THE KNOWLEDGE ECONOMY IN TOURISM: ESSENCE, COMPONENTS, AND ROLE IN DESTINATION COMPETITIVENESS

Pysareva I.
O.M. Beketov National University of Urban Economy in Kharkiv, Ukraine, PhD
DOI: 10.5281/zenodo.21095194

АНОТАЦІЯ

У статті досліджено теоретичні засади економіки знань у туризмі, визначено її сутність, основні складові та роль у формуванні конкурентоспроможності туристичних дестинацій. Обґрунтовано, що в умовах глобалізаційних трансформацій, цифровізації, посилення конкуренції між туристичними територіями та зміни структури туристичного попиту знання набувають значення стратегічного ресурсу розвитку туристичної сфери. Доведено, що конкурентоспроможність сучасних дестинацій дедалі меншою мірою залежить лише від природно-рекреаційного, історико-культурного чи інфраструктурного потенціалу, а визначається здатністю територій генерувати, накопичувати, поширювати та ефективно використовувати знання.

Економіку знань у туризмі запропоновано розглядати як систему економічних, управлінських, освітніх, інноваційних, інформаційних і комунікаційних процесів, спрямованих на створення та практичне застосування знань для забезпечення сталого розвитку туристичних дестинацій. Визначено, що її ключовими складовими є людський капітал, освітньо-науковий потенціал, цифрові технології, інформаційні ресурси, інновації, управлінські компетентності та мережеві взаємодії між суб'єктами туристичної системи.

Обґрунтовано, що вплив економіки знань на конкурентоспроможність туристичних дестинацій проявляється через підвищення якості туристичних послуг, формування інноваційних туристичних продуктів, персоналізацію туристичного досвіду, цифровізацію сервісів, посилення бренду території, розвиток smart-дестинацій та підвищення адаптивності до кризових явищ. Особливу увагу приділено значенню економіки знань для України в умовах воєнних викликів, трансформації туристичного попиту та потреби післявоєнного відновлення галузі. Зроблено висновок, що економіка знань є системним чинником модернізації туризму та стратегічною основою забезпечення довгострокової конкурентоспроможності туристичних дестинацій.

ABSTRACT

This article examines the theoretical foundations of the knowledge economy in tourism, defining its essence, key components and role in shaping the competitiveness of tourist destinations. It is argued that, in the context of globalisation, digitalisation, intensifying competition between tourist destinations and changes in the structure of tourist demand, knowledge is becoming a strategic resource for the development of the tourism sector. It is demonstrated that the competitiveness of modern destinations depends to an ever-decreasing extent solely on natural-recreational, historical-cultural or infrastructural potential, and is instead determined by the ability of regions to generate, accumulate, disseminate and effectively utilise knowledge.

It is proposed that the knowledge economy in tourism be viewed as a system of economic, managerial, educational, innovative, informational and communication processes aimed at the creation and practical application of knowledge to ensure the sustainable development of tourist destinations. It has been established that its key components are human capital, educational and scientific potential, digital technologies, information resources, innovation, managerial competencies and network interactions between actors in the tourism system.

It is argued that the impact of the knowledge economy on the competitiveness of tourist destinations manifests itself through improved quality of tourist services, the development of innovative tourist products, personalisation of the tourist experience, digitalisation of services, strengthening of the destination's brand, development of smart destinations, and increased resilience to crises. Particular attention is paid to the significance of the knowledge economy for Ukraine in the context of military challenges, the transformation of tourism demand, and the need for post-war recovery of the sector. It is concluded that the knowledge economy is a systemic factor in the modernisation of tourism and a strategic foundation for ensuring the long-term competitiveness of tourist destinations.

Ключові слова: економіка знань; туризм; туристична дестинація; конкурентоспроможність; інновації в туризмі; людський капітал; цифровізація туризму; управління знаннями.

Keywords: knowledge economy; tourism; tourist destination; competitiveness; innovation in tourism; human capital; digitalization of tourism; knowledge managemen.

Вступ.

В умовах глобалізаційних трансформацій, цифровізації суспільно-економічних процесів та загострення конкуренції між туристичними дестинаціями знання набувають значення одного з провідних стратегічних ресурсів розвитку туристичної сфери. Якщо в межах традиційних підходів конкурентоспроможність дестинацій переважно пов'язувалася з наявністю природно-рекреаційного, історико-культурного та інфраструктурного потенціалу, то в сучасних умовах дедалі більшої ваги набувають інтелектуальний капітал, інноваційна активність, цифрові технології, якість управління, здатність до продукування, акумуляції та ефективного використання знань. У цьому аспекті економіка знань постає як важлива концептуальна основа дослідження чинників розвитку туристичних територій та формування їхніх стійких конкурентних переваг.

Актуальність дослідження економіки знань у сфері туризму зумовлена високою динамічністю туристичного ринку, його залежністю від змін споживчих уподобань, технологічних інновацій, інформаційних потоків, безпекових ризиків і глобальних викликів. Сучасний туристичний попит дедалі більшою мірою орієнтується не лише на цінову доступність, просторову близькість чи ресурсну привабливість дестинації, а й на якість інформаційного супроводу, рівень персоналізації послуг, цифрову зручність, унікальність туристичного досвіду, безпеку, сталість та автентичність пропозиції. Це актуалізує необхідність системного використання знань у процесах стратегічного планування, управління, маркетингу, брендингу, цифровізації та інноваційного розвитку туристичних дестинацій.

Економіка знань у туризмі може бути розглянута як система взаємопов'язаних процесів створення, накопичення, трансферу, поширення та практичного застосування знань з метою підвищення ефективності функціонування туристичної сфери. Її структурними компонентами є людський капітал, освітньо-науковий потенціал, інформаційно-комунікаційні технології, інноваційна інфраструктура, цифрові платформи, управлінські компетентності, мережеві взаємодії між суб'єктами туристичного ринку, а також інституційна спроможність дестинації до адаптації в умовах нестабільності зовнішнього середовища. Поєднання зазначених складових створює передумови для підвищення якості туристичних послуг, формування інноваційних туристичних продуктів, посилення брендової ідентичності територій та зміцнення їхньої конкурентоспроможності.

Особливого значення економіка знань набуває в контексті розвитку туристичних дестинацій за умов кризових явищ, зокрема соціально-економічної нестабільності, екологічних загроз, безпекових викликів і воєнних ризиків. Для України зазначена проблематика має особливу актуальність, оскільки відновлення туристичної сфери потребує не лише реконструкції матеріальної інфраструктури, а й упровадження нових підходів до управління дестинаціями, розвитку людського капіталу, цифровізації туристичних сервісів, просування територіальних брендів і формування інноваційних моделей туристичного продукту. У цьому контексті знання виступають не допоміжним ресурсом, а системоутворювальним чинником відновлення, модернізації та сталого розвитку туризму.

Аналіз досліджень і публікацій.

Проблематика економіки знань у туризмі формується на перетині досліджень економіки знань, інноваційного розвитку, цифровізації, управління знаннями та конкурентоспроможності туристичних дестинацій. Теоретичні засади економіки знань закладено у працях П. Друкера [1], який обґрунтував зростання ролі знань як ключового ресурсу постіндустріального суспільства. У документах OECD [2] економіка знань розглядається як модель розвитку, що базується на створенні, поширенні та використанні знань, інформації, інновацій і людського капіталу.

Вагомий внесок у дослідження конкурентоспроможності туристичних дестинацій здійснили Дж. Ритчі та Дж. Крауч [3], які запропонували комплексну модель конкурентоспроможності дестинації з урахуванням ресурсного потенціалу, управління, маркетингу, політики розвитку та зовнішнього середовища. Л. Дваєр і Ч. Кім [4] розглядають конкурентоспроможність дестинації через поєднання наявних і створених ресурсів, управлінських чинників та соціально-економічних результатів. Ці підходи дозволяють трактувати знання, інновації, цифрові технології й управлінські компетентності як важливі джерела конкурентних переваг туристичних територій.

У зарубіжних дослідженнях значна увага приділяється зв'язку між знаннями, інноваціями та розвитком туризму. К. Х'ялаґер [5] доводить, що інновації у продуктах, процесах, організаційних моделях і ринкових підходах є важливою умовою конкурентоспроможності туристичних підприємств і дестинацій. Р. Баджо та К. Купер [6] розглядають дестинацію як мережу взаємопов'язаних суб'єктів, у межах якої обмін знаннями та їх трансфер впливають на інноваційну активність і здатність території адаптуватися до змін.

Окремий науковий напрям становлять дослідження smart tourism destination. Д. Бухаліс та А. Амаранггана [7] зазначають, що «розумні» дестинації формуються на основі інтеграції інформаційно-комунікаційних технологій, цифрових платформ, інноваційного управління та взаємодії між туристами, бізнесом, владою і громадою. У. Гретцель та співавтори [8] підкреслюють, що smart tourism ґрунтується на використанні цифрових даних, технологічної інфраструктури, мережевої взаємодії та персоналізації туристичного досвіду. К. Боес, Д. Бухаліс та А. Інверсіні [9] пов'язують розвиток smart-дестинацій із посиленням конкурентоспроможності територій і створенням нових моделей туристичної цінності.

Українські науковці також досліджують питання конкурентоспроможності, цифровізації та інноваційного розвитку туризму. Т. Калина, Т. Арзуманян, Т. Устік [11] аналізують чинники формування конкурентних переваг туристичних дестинацій. Н. Почерніна [12] розглядає конкурентоспроможність туристичної сфери економічних районів України та підходи до її оцінювання. Т. Лисюк [13] із колегами досліджують інноваційні інформаційні

процеси у розвитку туризму, а М. Шевелюк [14] розкриває цифровізацію як один із провідних трендів модернізації туристичної сфери. О. Пустовіт [15] акцентує увагу на впливі цифрових технологій на конкурентоспроможність туристичних компаній. І. Писарева та К. Яловнича [16] розглядають управління розвитком туристичних дестинацій в умовах цифровізації та глобальних викликів.

Аналіз наукових джерел свідчить, що в зарубіжній літературі економіка знань у туризмі переважно досліджується через інновації, управління знаннями, smart-дестинації, цифрові платформи та людський капітал. В українському науковому дискурсі основна увага зосереджена на конкурентоспроможності дестинацій, цифровізації туризму та регіональному розвитку. Водночас недостатньо розкритими залишаються питання комплексного теоретичного обґрунтування сутності економіки знань у туризмі, систематизації її складових та визначення ролі у формуванні довгострокових конкурентних переваг туристичних дестинацій.

Постановка задачі.

Незважаючи на посилення наукової уваги до проблематики економіки знань, цифрової трансформації, інноваційного розвитку та забезпечення конкурентоспроможності туристичних дестинацій, питання формування й функціонування економіки знань у сфері туризму досі не набуло належного рівня теоретичної систематизації. У наявних наукових дослідженнях переважно акцентується увага на окремих її компонентах, зокрема цифрових технологіях, людському капіталі, інноваційній діяльності, інформаційних ресурсах та управлінні туристичними дестинаціями. Водночас подальшого наукового уточнення потребують сутнісні характеристики економіки знань у туризмі, її структурні елементи та роль у формуванні стійких конкурентних переваг туристичних територій.

Метою статті є теоретичне обґрунтування сутності економіки знань у туризмі, систематизація її ключових складових та визначення її ролі у забезпеченні конкурентоспроможності туристичних дестинацій.

Виклад основного матеріалу.

У сучасних умовах трансформації світової економіки, цифровізації суспільних процесів та посилення міжрегіональної і міжнародної конкуренції туристична сфера дедалі більшою мірою залежить від здатності генерувати, накопичувати, поширювати та ефективно використовувати знання. Саме знання, інновації, інформаційні ресурси, цифрові технології, людський капітал та якість управлінських рішень поступово перетворюються на ключові чинники розвитку туристичних дестинацій. Якщо в традиційних підходах конкурентоспроможність територій переважно пов'язувалася з наявністю природно-рекреаційних, історико-культурних, інфраструктурних і географічних переваг, то в умовах економіки знань визначального значення набуває спроможність дестинації перетворювати наявний ресурсний потенціал на якісний, інноваційний і конкурентоспроможний туристичний продукт.

Економіку знань у туризмі доцільно розглядати як систему економічних, управлінських, освітніх, інноваційних, інформаційних і комунікаційних процесів, спрямованих на створення, трансфер, поширення та практичне використання знань для забезпечення сталого розвитку туристичної сфери. Її сутність полягає не лише в накопиченні інформації про туристичні ресурси, попит або ринки, а й у здатності суб'єктів туристичної діяльності застосовувати ці знання для прийняття ефективних управлінських рішень, формування нових туристичних продуктів, підвищення якості сервісу, персоналізації туристичного досвіду, розвитку бренду дестинації та посилення її конкурентних позицій.

У межах такого підходу знання виступають стратегічним нематеріальним ресурсом туристичної дестинації. Вони забезпечують можливість глибшого розуміння потреб споживачів, прогнозування змін туристичного попиту, оцінювання ресурсного потенціалу території, визначення перспективних ринкових ніш і розроблення інноваційних моделей розвитку. На відміну від матеріальних ресурсів, знання не вичерпуються у процесі використання, а навпаки — можуть накопичуватися, оновлюватися, поширюватися між учасниками туристичної системи та створювати мультиплікативний ефект для розвитку дестинації.

Однією з провідних складових економіки знань у туризмі є людський капітал, який охоплює професійні знання, компетентності, практичні навички, креативність, комунікаційну культуру, цифрову грамотність і здатність персоналу до інноваційної діяльності. У туристичній сфері людський капітал має особливе значення, оскільки якість туристичного продукту безпосередньо залежить від рівня підготовки кадрів, їхньої клієнтоорієнтованості, здатності до міжкультурної комунікації, адаптації до нових запитів туристів та використання сучасних сервісних технологій. Саме людський капітал забезпечує перетворення наявних туристичних ресурсів на цілісний туристичний досвід, що має споживчу цінність.

Важливою складовою економіки знань є освітньо-науковий потенціал, який формує інтелектуальну основу розвитку туристичних дестинацій. Заклади вищої освіти, науково-дослідні установи, професійні асоціації, експертні платформи та центри підготовки кадрів забезпечують продукування нових знань, проведення прикладних досліджень, підготовку фахівців, розроблення інноваційних туристичних продуктів і поширення сучасних управлінських практик. У цьому контексті університети можуть виконувати не лише освітню функцію, а й роль інституційних драйверів регіонального туристичного розвитку, беручи участь у стратегічному плануванні, розробленні туристичних маршрутів, брендингу територій, аналітичному супроводі управлінських рішень і підготовці кадрів для майбутнього відновлення галузі.

Інформаційно-комунікаційні технології є однією з ключових основ функціонування економіки знань у туризмі. Вони забезпечують збирання, оброблення, систематизацію та використання вели-

ких обсягів даних про туристичні потоки, поведінку споживачів, рівень задоволеності туристів, ефективність маркетингових комунікацій, стан туристичної інфраструктури та якість послуг. Використання цифрових платформ, мобільних застосунків, систем онлайн-бронювання, CRM-систем, геоінформаційних технологій, віртуальних турів, електронних карт, соціальних мереж та інструментів аналітики даних сприяє підвищенню доступності туристичної інформації, персоналізації пропозиції, розширенню каналів комунікації з туристами та підвищенню ефективності управління дестинацією.

Особливого значення в сучасних умовах набуває концепція smart-дестинації, яка є практичним проявом економіки знань у туризмі. Smart-дестинація ґрунтується на інтеграції цифрових технологій, інноваційного управління, відкритих даних, сталого розвитку, партнерської взаємодії та орієнтації на якісний туристичний досвід. У таких дестинаціях знання та дані використовуються для оптимізації туристичних потоків, підвищення безпеки, управління навантаженням на інфраструктуру, збереження культурної спадщини, покращення доступності послуг і формування більш гнучкої та персоналізованої туристичної пропозиції.

Інноваційна складова економіки знань проявляється у здатності туристичної системи створювати нові продукти, послуги, бізнес-моделі, формати обслуговування та способи взаємодії зі споживачами. Інновації у туризмі можуть мати продуктовий, процесний, організаційний, маркетинговий, соціальний або екологічний характер. Вони охоплюють розвиток креативного, гастрономічного, подієвого, культурного, освітнього, медичного, рекреаційного, екологічного та інших видів туризму, а також упровадження нових підходів до управління якістю, безпекою, доступністю та сталістю туристичних послуг. Завдяки інноваціям дестинації отримують можливість диференціювати свою пропозицію, формувати унікальну цінність для туриста та зміцнювати власну ринкову позицію.

Не менш важливою є управлінська складова економіки знань. Ефективне управління туристичною дестинацією в умовах економіки знань має ґрунтуватися на використанні аналітичної інформації, результатів наукових досліджень, цифрових даних, експертних оцінок, стратегічного планування та постійного моніторингу змін зовнішнього середовища. Управлінські рішення повинні бути не ситуативними, а доказовими, тобто спиратися на комплексний аналіз туристичного попиту, конкурентного середовища, ресурсного потенціалу, інфраструктурних можливостей, ризиків і очікувань стейкхолдерів. Такий підхід дозволяє підвищити обґрунтованість політики розвитку дестинацій і забезпечити їхню адаптивність до глобальних і локальних викликів.

Економіка знань у туризмі має виразний мережевий характер, оскільки туристична дестинація функціонує як складна система взаємодії багатьох суб’єктів: органів державної та місцевої влади, туристичного бізнесу, закладів освіти, наукових установ, громадських організацій, місцевих громад, інвесторів і самих туристів. Саме через мережеву взаємодію відбуваються обмін знаннями, поширення інновацій, формування спільних туристичних продуктів, узгодження стратегічних пріоритетів і просування територіального бренду. Наявність ефективних комунікаційних каналів між стейкхолдерами підвищує інституційну спроможність дестинації та сприяє формуванню партнерської моделі управління.

Вплив економіки знань на конкурентоспроможність туристичних дестинацій проявляється у кількох взаємопов’язаних напрямах (Рис.1):

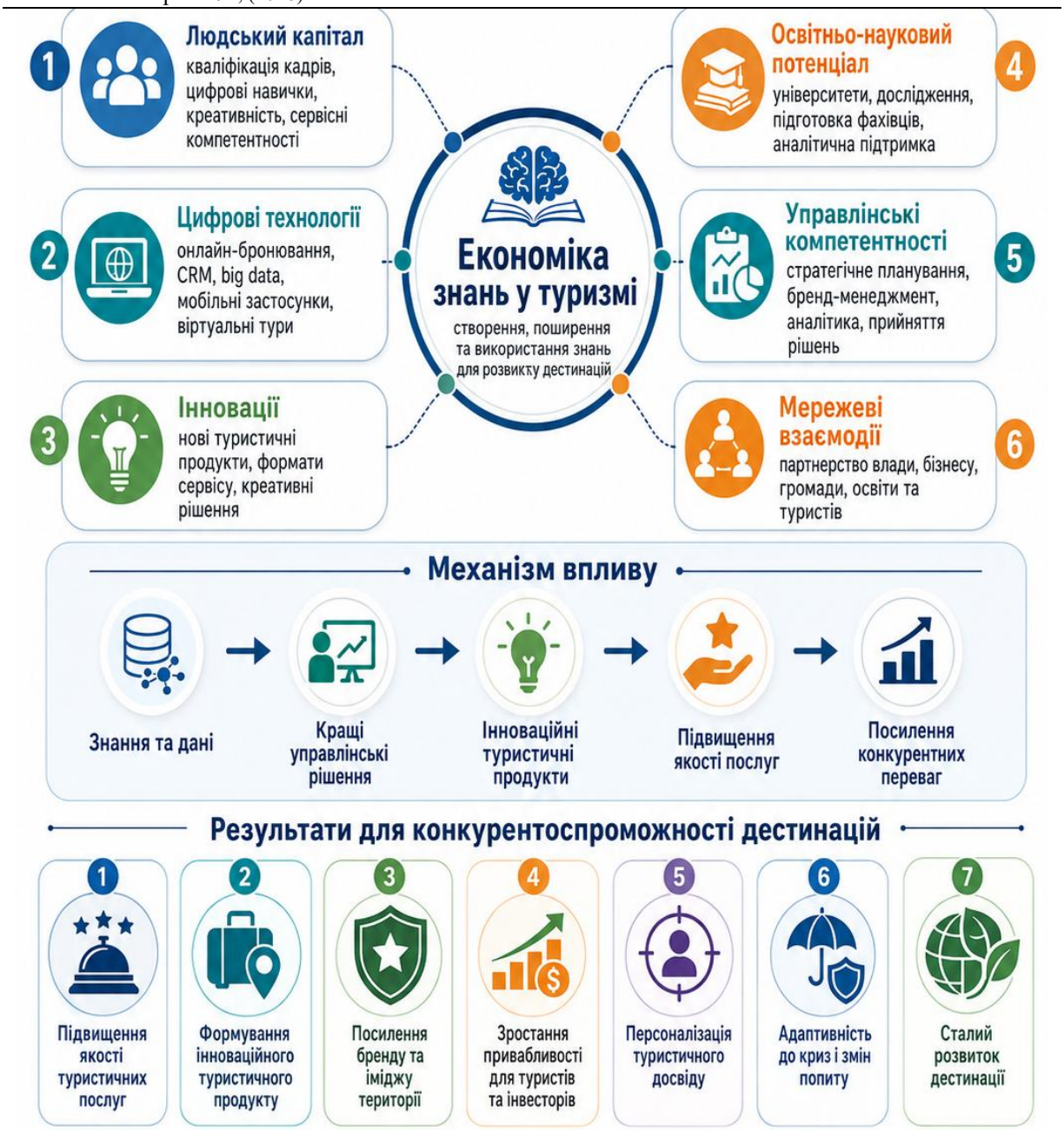
Людський капітал
кваліфікація кадрів, цифрові навички, креативність, сервісні компетентності
Цифрові технології
онлайн-бронювання, CRM, big data, мобільні застосунки, віртуальні тури
Інновації
нові туристичні продукти, формати сервісу, креативні рішення
Економіка знань у туризмі
створення, поширення та використання знань для розвитку дестинацій
Освітньо-науковий потенціал
університети, дослідження, підготовка фахівців, аналітична підтримка
Управлінські компетентності
стратегічне планування, бренд-менеджмент, аналітика, прийняття рішень
Мережеві взаємодії
партнерство влади, бізнесу, громади, освіти та туристів
Механізм впливу
Знання та дані
Кращі управлінські рішення
Інноваційні туристичні продукти
Підвищення якості послуг
Посилення конкурентних переваг
Результати для конкурентоспроможності дестинацій
Підвищення якості туристичних послуг
Формування інноваційного туристичного продукту
Посилення бренду та іміджу території
Зростання привабливості для туристів та інвесторів
Персоналізація туристичного досвіду
Адаптивність до криз і змін попиту
Сталий розвиток дестинації

Рис.1. Вплив економіки знань на конкурентоспроможність туристичних дестинацій

– сприяє підвищенню якості туристичних послуг через упровадження стандартів сервісу, професійну підготовку кадрів і використання сучасних технологій обслуговування;

– забезпечує створення інноваційних туристичних продуктів, здатних задовольняти змінні потреби споживачів;

– посилює маркетингову спроможність дестинації шляхом використання цифрових каналів комунікації, аналітики даних і персоналізованих стратегій просування;

– сприяє формуванню позитивного іміджу та бренду території;

– підвищує стійкість дестинації до кризових явищ завдяки здатності швидко адаптувати управлінські рішення до нових умов.

Для України розвиток економіки знань у туризмі має особливе значення в контексті воєнних викликів, трансформації туристичного попиту та потреби у післявоєнному відновленні галузі. Відновлення туристичних дестинацій не може обмежуватися лише реконструкцією інфраструктури або відновленням матеріальної бази. Воно потребує оновлення управлінських моделей, розвитку цифрових сервісів, підготовки кваліфікованих кадрів, переосмислення туристичних продуктів, створення безпечних маршрутів, актуалізації культурної спадщини, формування нових наративів територіального брендингу та активного залучення місцевих громад до туристичного розвитку. У цьому контексті економіка знань виступає одним із ключових механізмів модернізації та підвищення стійкості туристичної сфери.

Висновки.

Економіка знань у туризмі є комплексною системою, що поєднує людський капітал, освітньо-на-

уковий потенціал, цифрові технології, інформаційні ресурси, інновації, управлінські компетентності та мережеві взаємодії. Її розвиток створює передумови для підвищення якості туристичних послуг, формування інноваційних туристичних продуктів, посилення бренду дестинацій, розширення їхньої ринкової присутності та забезпечення довгострокових конкурентних переваг. Саме тому економіка знань має розглядатися як стратегічний чинник конкурентоспроможності туристичних дестинацій у сучасних умовах глобальних трансформацій.

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ECOLOGICAL CLEANING AS A SEGMENT OF SUSTAINABLE BUSINESS IN THE CONTEXT OF GROWING CONSUMER AWARENESS

Rakhmanska T.
Master's degree in Mechanical Engineering, CTO Wow Now Cleaning LLC / CEO Wow Now Ua Inc, Wow Now Cleaning LLC / Wow Now Ua Inc, Tampa, FL, USA
https://orcid.org/0009-0000-4029-9551
DOI: 10.5281/zenodo.21095225

ABSTRACT

This article examines eco-friendly cleaning as a promising segment of sustainable business, situated at the intersection of growing demand for safe domestic and commercial services, the development of green marketing, the strengthening of consumer environmental responsibility, and the transformation of service-based business models. The study demonstrates that eco-friendly cleaning cannot be regarded solely as the use of "green" cleaning products, as its scope encompasses chemical safety, reduction of indoor air quality impacts, resource conservation, waste minimization, transparent client communication, staff training, and greenwashing prevention. It is established that rising consumer awareness creates for cleaning service enterprises not only reputational advantages but also new requirements concerning the substantiation of environmental claims, service quality, and price accessibility. A generalized model of factors that determine the development of eco-friendly cleaning as a sustainable business segment is proposed. The practical significance of the study lies in the systematization of criteria by which enterprises can develop competitive eco-friendly cleaning service offerings without compromising consumer trust.

Keywords: eco-friendly cleaning, sustainable business, green marketing, consumer awareness, environmental services, greenwashing, circular economy.

Introduction

The growth of consumer environmental awareness is gradually reshaping the structure of demand for everyday goods and services. While environmental consciousness was previously associated primarily with energy, transportation, food products, or packaging, in recent years it has increasingly extended into the domain of domestic and commercial services. Among such services is eco-friendly cleaning, which combines a sanitary function with concern for the health of building occupants and the reduction of adverse environmental impacts. For businesses, this represents a transition from the straightforward provision of cleaning services to the development of a comprehensive value proposition, in which cleanliness is assessed not only through visual results but also through the safety of products used, the transparency of processes, and the responsible use of resources.

The relevance of this topic is further reinforced by the fact that everyday goods and services represent the most immediate arena in which consumers can practically express their environmental stance. Research into the purchasing behavior of consumers of eco-friendly cleaning products has demonstrated that a positive attitude toward such products does not automatically translate into stable purchasing behavior, as decisions are influenced by price, quality, availability, convenience, and trust in a company's environmental claims [1, p. 53]. Consequently, the development of eco-friendly cleaning requires not a declarative approach but an economically, technologically, and communicatively grounded model.

In a broader context, green consumer behavior is shaped by environmental knowledge, social norms, personal values, income level, and prior experience with eco-friendly products. A systematic review of green consumption research indicates that consumers do not constitute a homogeneous group, and that purchasing decisions regarding eco-friendly products are determined by a combination of psychological, sociodemographic, and contextual factors [2, p. 2]. This conclusion is equally relevant to cleaning services, as consumers evaluate not abstract environmental credentials but specific practical benefits: clean indoor air, the absence of harsh odors, reduced risk of allergic reactions, minimization of plastic waste, and the alignment of claimed quality with actual results.

The theoretical significance of this study lies in the necessity of examining eco-friendly cleaning as a distinct segment of sustainable business, rather than merely as a variety of cleaning service or a marketing label for the use of natural products. Contemporary models of sustainable consumption emphasize that consumer behavior depends on a combination of intentions, knowledge, social influences, value orientations, and the real-world accessibility of sustainable alternatives [3, p. 1]. Accordingly, enterprises operating in the eco-friendly cleaning sector must simultaneously address the challenges of service quality, process safety, evidence-based communication, and the economic viability of their business model.

Literature Review

Recent scholarly literature provides grounds for examining eco-friendly cleaning at the intersection of three research directions: the safety of cleaning and disinfecting agents, green consumer behavior, and sustainable business models. Within the first direction, particularly significant are studies addressing the effects of cleaning products on indoor air quality and human health. A review by H. Salonen, T. Salthammer, E. Castagnoli, M. Täubel, and L. Morawska synthesizes data on the chemical composition of surface cleaning agents, the risks associated with volatile organic compounds, particulate matter, fragrances, and disinfecting components, and emphasizes the need for careful product selection and improved ventilation during and after cleaning procedures [4].

Empirical studies indicate that the classification of products as "conventional" or "green" is not always sufficient for assessing their actual safety. A. M. Temkin, S. L. Geller, S. A. Swanson, N. S. Leiba, O. V. Naidenko, and D. Q. Andrews documented emissions of hundreds of volatile organic compounds from various categories of cleaning products, while noting that certified or fragrance-free green products may reduce risks compared to conventional alternatives [5, p. 1]. At the same time, E. Harding-Smith, D. R. Shaw, M. Shaw, T. J. Dillon, and N. Carslaw demonstrated that certain green products may also generate substantial monoterpene emissions, indicating that environmental credentials must be substantiated by ingredient composition, substance concentration, and conditions of use, rather than by marketing positioning alone [6, p. 437].

The second research direction concerns green marketing and consumer behavior. Skackauskiene I. and N. Vilkaite-Vaitone, drawing on a systematic review of 166 articles, demonstrated that green marketing influences purchase intentions, actual behavior, and post-purchase loyalty, but that its effectiveness depends on the level of application: strategic, tactical, or operational [7, p. 13]. For eco-friendly cleaning, this implies that it is insufficient merely to advertise "environmental friendliness"; the declared value must be aligned with procurement processes, staff training, quality control, and client communication.

Eco-labels, digital reviews, and user-generated content play a distinct role in building consumer trust. Panopoulos A., A. Poulis, P. Theodoridis, and A. Kalampakas demonstrated that eco-labels and user-generated content can strengthen purchase intentions for green products, as they reduce informational uncertainty and render environmental attributes more salient to consumers [8]. For cleaning service companies, this creates a need not only to use certified products but also to provide clear explanations of which products are used, why they are safer, and what their limitations are.

At the same time, the literature draws attention to the risk of greenwashing. Sun Y. and B. Shi demonstrated that the perception of greenwashing reduces green purchase intentions, with the negative effect being amplified when consumers exhibit higher levels of environmental responsibility [9, p. 10]. This is particularly significant in the cleaning services sector, as clients typically do not monitor the full service delivery process and are compelled to trust the company regarding product composition, dosage, packaging disposal, and the safety of procedures employed.

The third direction encompasses sustainable and circular business models. A. T. Rosário, P. Lopes, and F. S. Rosário emphasize that the circular economy transforms the logic of value creation: businesses must transition from linear resource consumption to models that incorporate reuse, waste reduction, and long-term environmental responsibility [10]. In the service sector, this logic is associated with the opportunity to deliver outcomes in the format of a responsible service rather than selling discrete products. Alcayaga A. and E. G. Hansen demonstrate that circular service models require the alignment of value propositions, digital support, resource efficiency, and consumer engagement [11, p. 512].

Contemporary studies also address the generational dimension. Filip A., A. Stancu, L.-F. Onișor, O. C. Mogoș, S.-A. Catană, and D. Goldbach, analyzing Generation Z purchase intentions regarding eco-friendly products, identified the influence of perceived quality, ethical orientations, and trust in product attributes [12]. For eco-friendly cleaning, this implies that future demand, particularly among younger consumer groups and corporate clients with ESG policies, will depend on the capacity of businesses to demonstrate the tangible benefits of their services.

Identification of Previously Unresolved Aspects of the Problem

Despite the active development of research on green consumption, environmental marketing, and the chemical safety of cleaning agents, eco-friendly cleaning as a distinct segment of sustainable business remains insufficiently systematized. Scholarly works frequently examine in isolation consumer willingness to purchase eco-friendly products, the effects of green marketing, or the properties of cleaning agents. Less thoroughly addressed, however, is the question of how these components are integrated within a service-based business model in which the end product is not a cleaning agent but a safe, high-quality, and environmentally justified service.

Also unresolved is the problem of distinguishing genuinely eco-friendly cleaning from the marketing appropriation of environmental rhetoric. For consumers, the terms "eco," "natural," "green," "safe," and "non-toxic" are frequently perceived as interchangeable, yet from a scientific standpoint they are not equivalent. In the absence of clear criteria concerning product composition, conditions of application, equipment reuse, chemical dosage, waste management, and certification transparency, eco-friendly cleaning risks becoming an instrument of image-driven positioning rather than substantive practice.

The economic dimension of this issue also warrants separate consideration. Eco-friendly cleaning is frequently associated with higher costs related to product procurement, staff training, certification, and client communication. At the same time, these very expenditures may generate added value when consumers understand their significance and associate them with service quality, safety, and corporate responsibility. It is therefore important to determine under what conditions eco-friendly cleaning becomes not only an ethical choice but also a viable segment of sustainable entrepreneurship.

The **aim of this article** is to provide a theoretical and analytical justification for eco-friendly cleaning as a segment of sustainable business in the context of growing consumer awareness, and to identify the key factors that influence the formation of a competitive yet responsible cleaning service offering.

To achieve this aim, the following methods were employed: analysis of current scholarly literature, systematization of approaches to green consumption, comparative generalization of eco-friendly cleaning practices, and logical modeling of the components of a sustainable service offering. The source base comprised scientific publications from 2022 to 2025 addressing green marketing, sustainable consumption, the safety of

cleaning agents, greenwashing, and circular business models.

Research Results

Eco-friendly cleaning should be regarded as a comprehensive service practice encompassing product selection, work execution technology, staff organization, client communication, and post-service accountability. This approach distinguishes it from a narrow interpretation in which environmental credentials are reduced to the mere substitution of one cleaning agent for another. In sustainable business, the environmental characterization of a service must be verified at every stage of value creation: from the procurement of concentrates and materials to packaging disposal, water consumption monitoring, and procedure documentation.

The first foundational element is chemical and hygienic safety. Demand for eco-friendly cleaning arises not only from environmental concern but also from the practical need to reduce risks for individuals who live or work in spaces following cleaning procedures. This is particularly relevant for children, elderly persons, and individuals with asthma, allergies, or heightened sensitivity to fragrances. However, a specific complexity arises at this point: a "green" product does not automatically signify a safer product under all conditions. Scientific data on volatile organic compound emissions indicate that the determining factors are composition, concentration, method of application, ventilation, and frequency of use, rather than product labeling or marketing positioning alone [6, p. 438].

The second element is resource efficiency. Eco-friendly cleaning must incorporate not only safer products but also the conservative use of water, electricity, single-use materials, and plastic packaging. In business practice, this may be expressed through the use of concentrated products, reusable microfiber cloths, dispensing systems, staff route planning, reduction of the transportation footprint, and the adoption of energy-efficient equipment. In this respect, eco-friendly cleaning converges with the logic of the circular economy, as it generates value not through an increase in the quantity of materials consumed but through process optimization and waste reduction [10].

The third element is transparent communication. For the consumer, eco-friendly cleaning is frequently an "invisible" service: the client observes a clean space but does not always know which substances were used, how they were dosed, whether the products were certified, how packaging was disposed of, or whether safety protocols were followed. A service company must therefore translate complex technical specifications into language accessible to the client: explaining product selection, providing certification information, stating limitations, and avoiding absolute claims such as "completely safe" or "entirely natural" unless these are substantiated.

The fourth element is the business model. Eco-friendly cleaning can be sustainable only when it does not remain a one-time premium service available to a narrow client base. This requires service formats that combine affordability and cost predictability: subscription-based maintenance, office packages, services for educational, medical, and social institutions, post-renovation cleaning with dust and volatile compound monitoring, and consultancy support for safe facility maintenance. The circular service logic enables a shift in emphasis from the sale of individual products to the delivery of long-term outcomes: a clean, safe, and resource-efficient environment [11, p. 516].

Table 1 demonstrates that eco-friendly cleaning cannot be reduced to a single technological parameter. Its competitiveness derives from the integration of material, service, and communicative components.

Table 1

Key Components of Eco-Friendly Cleaning as a Sustainable Business Segment

	Content in Cleaning Service	Expected Consumer Value	Business Effect
Safer cleaning agents	Use of certified or less toxic cleaning products, control of fragrances, dosage, and ventilation	Reduced concern regarding odors, allergic reactions, and indoor air quality	Building of consumer trust and differentiation from conventional cleaning
Resource efficiency	Reduction of water, electricity, single-use material, and plastic packaging consumption	Sense of participation in responsible consumption without loss of service quality	Reduction of operational waste and support for sustainable market positioning
Communication transparency	Explanation of product composition, procedures, certification, and limitations of environmental claims	Reduction of informational uncertainty and risk of consumer distrust	Protection against reputational damage and greenwashing allegations
Staff training	Instruction in safe dosage practices, product handling, equipment use, and waste management	Consistent service quality regardless of individual service provider	Enhanced professionalism and reduced procedural errors
Service-based business model	Subscription packages, long-term contracts, corporate programs, and consultancy support	Convenience, cost predictability, and regular service outcomes	Repeat sales, client loyalty, and more stable revenue streams

Source: compiled by the author based on a synthesis of current research on green consumption, cleaning agent safety, and sustainable business models [4–6].

When a company uses safer cleaning agents but fails to explain their properties to the client, the consumer may not recognize the added value. When a company actively promotes its environmental credentials but does not monitor product dosage, composition, and waste management, the risk of consumer distrust increases. When a service is excessively expensive or inconvenient, even an environmentally conscious client may revert to a conventional alternative.

From this follows the first finding of the theoretical synthesis: eco-friendly cleaning emerges as a segment of sustainable business only when environmental value is integrated into the operational process. In this case, sustainability is not an additional advertising attribute but becomes the organizing principle of service delivery. The company must exercise control over procurement, staff training, performance standards, resource consumption, and post-service communication. It is precisely this integration that enables the elimination of the gap between declared and actual environmental performance.

The second finding is that consumer awareness functions not only as a source of demand but also as a mechanism of accountability. The greater a consumer's knowledge of environmental risks, the more critically they evaluate vague or exaggerated corporate claims. This is consistent with conclusions regarding the negative effect of greenwashing on green purchase intentions [9, p. 11].

In the cleaning services sector, this pattern implies that companies must avoid vague formulations and instead disclose specific parameters: product types, certification details, dosage methods, recommended ventilation conditions, packaging approaches, and equipment reuse practices.

The third finding concerns price sensitivity. Green services are frequently perceived as more expensive, and their market prospects therefore depend on the ability of businesses to explain precisely what the client is paying for. When added value is presented solely as an abstract concern for the environment, it may prove insufficiently persuasive. By contrast, the combination of environmental and personal benefit, including fewer irritating odors, a safer environment for children or employees, reduced indoor air pollution risk, and alignment with corporate sustainability policies, renders the price more justifiable to the consumer.

The fourth finding is that eco-friendly cleaning has development potential in both the B2C and B2B segments. For households, it is associated with residential environment safety and responsible consumption. For corporate clients, it may constitute a component of corporate responsibility policy, occupational health management, ESG reporting, reputation management, and employee wellbeing initiatives. In the corporate segment, the standardization of procedures, documentation of products used, and regularity of service delivery are of particular importance.

The fifth finding concerns the role of younger consumer groups. Generation Z and younger professional cohorts more frequently expect from companies not only functional outcomes but also alignment with ethical and environmental values. However, as current research on eco-friendly product purchase intentions indicates, quality, trust, and perceived usefulness remain the primary determinants even for environmentally oriented consumers [12]. Eco-friendly cleaning therefore cannot be promoted exclusively through moral appeals; it must demonstrate concrete service quality.

In practical terms, the development of eco-friendly cleaning requires a phased strategy. In the first phase, the enterprise identifies the products and procedures that can be replaced with safer or more resource-efficient alternatives. In the second phase, an internal service standard is established, encompassing dosage protocols, equipment specifications, ventilation procedures, rules governing the mixing or incompatibility of chemical substances, and waste management practices. In the third phase, clear client-facing communication is developed, in which environmental credentials are substantiated not by general slogans but by verifiable facts. In the fourth phase, the business model is adapted to different client segments: private households, offices, educational institutions, small businesses, and medical and social facilities.

Equally important is the avoidance of excessive promises. Eco-friendly cleaning does not imply the complete absence of chemical substances, absolute safety, or zero environmental impact. It is more accurate to speak of risk reduction, more judicious product selection, lower emissions of undesirable substances under specific conditions, waste minimization, and more responsible process organization. Such measured communication may appear less promotional, yet it more accurately reflects scientific evidence and reduces the risk of consumer trust erosion.

Eco-friendly cleaning thus represents a promising segment of sustainable business; however, its development depends on the capacity of enterprises to integrate technological safety, service quality, economic accessibility, and evidence-based communication. It is precisely this combination that transforms environmental credentials from an ancillary characteristic into the foundation of competitive advantage.

Conclusions and Recommendations

This article demonstrates that eco-friendly cleaning should be regarded as a distinct segment of sustainable business, shaped by the growth of consumer awareness, increasing demand for safe environments, and the advancement of green marketing. Its scope extends beyond the use of eco-friendly cleaning agents to encompass resource efficiency, chemical risk management, staff training, transparent communication, waste reduction, and long-term client trust.

It is established that the primary condition for the viability of this segment is the alignment between environmental claims and the actual organization of service delivery. When environmental credentials are employed solely as an advertising label, they rapidly lose credibility and may be perceived as greenwashing. By contrast, enterprises that document their product selection, explain cleaning procedures to clients, monitor resource consumption, and provide staff training are positioned to develop a durable competitive advantage.

It is proposed that the development of eco-friendly cleaning be examined through five interrelated compo-

nents: safer cleaning agents, resource efficiency, transparent communication, staff preparation, and a service-based business model. This framework enables eco-friendly cleaning to be assessed not on the basis of individual advertising attributes but on the integrity of the overall business process.

Practical recommendations for cleaning service enterprises include the introduction of internal eco-service standards, the use of evidence-based language in advertising, the avoidance of absolute environmental claims, the development of tiered pricing packages for different consumer segments, and the regular provision of information to clients regarding the products and procedures used.

Directions for further research should focus on the empirical examination of consumer willingness to pay for eco-friendly cleaning services, a comparative analysis of B2C and B2B demand, and an assessment of the actual impact of different cleaning practices on indoor air quality, resource consumption, and client trust levels.

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IMPROVEMENT OF PERSONNEL POLICY IN LOCAL SELF-GOVERNMENT BODIES USING THE EXAMPLE OF UKRAINE

Sobolev V.
Simon Kuznets Kharkiv National University of Economics,
Candidate of Economic Sciences, Associate Professor
Kovtun M.
Simon Kuznets Kharkiv National University of Economics, lecturer
DOI: 10.5281/zenodo.21095243

ABSTRACT

Improvement of personnel policy in local self-government bodies using the example of Ukraine is analyzed in the article. The purpose of the study is to develop measures to improve the process of implementing personnel policy in local self-government bodies. Developing a regulatory instrument for public sector human resources is essential. This instrument should define clear benchmarks for all government roles, guiding initial training, skill development, professional growth, and performance appraisals. Employees must understand their responsibilities, career paths, performance metrics, and the aims of their training. A competency-based methodology should underpin these assessment criteria. The civil service professional framework aims to outline regulatory duties and establish professional skills, ensuring employees meet job requirements and societal expectations.

Keywords: local self-government, personnel policy, improvement, Ukraine.

In modern conditions, with all the importance of managing material and financial resources, human resources management comes first. In this regard, the relevance of developing modern systems for selecting and nominating personnel, their effective training, and continuous professional development is increasing. Therefore, at the current stage of development of the statehood of Ukraine, resolving the issue of high-quality personnel provision for the socio-political and socio-economic spheres of life in Ukraine has become one of the priority tasks. The development and implementation of modern personnel policy in Ukraine in all spheres of social activity requires an effective personnel system, which includes a set of personnel institutes and organizational structures that carry out integrated management of personnel processes in order to achieve certain priorities for the development of society. The personnel process is a set of measures for training, retraining, selection, placement and education of personnel adequate to the requirements of the national personnel strategy, the corporate strategy of a separate organization. Work with personnel should include: career guidance, professional selection, professional training, professional retraining; placement and consolidation of personnel; improvement of the motivational mechanism of their activities; improvement of working conditions and attractiveness; professional certification, stimulation of professional growth; work with a personnel reserve; control over personnel activities; system of informing personnel about the tasks of collectives; personnel education. Therefore, the issue of increasing the effectiveness of personnel policy in public institutions of Ukraine, especially in local self-government bodies, becomes relevant.

In the process of work, the works of well-known domestic and foreign authors were studied, who paid special attention to the study of the theory of personnel policy, increasing its effectiveness. The theoretical basis of the work was the works of well-known domestic authors: O. Voronka, G. Shchokina, S. Dubenko. Certain aspects of the development of local self-government, the implementation of state personnel policy and personnel work in the regions of Ukraine are studied in scientific works and publications by O. Amosov, N. Gavkalova, V. Knyazev, N. Nyzhnyk, O. Yakovenko, V. Yatsuba, etc. However, this issue has not lost its relevance and requires further study. Therefore, it is necessary to investigate the problems and find ways to improve the implementation of personnel policy in local self-government bodies.

The purpose of the study is to develop measures to improve the process of implementing personnel policy in local self-government bodies.

Improving human resource potential in the field of local self-government.

The personnel policy of modern Ukraine for the most part does not meet modern requirements. Management at various levels does not have a program of actions regarding personnel, and the personnel process is reduced to eliminating negative consequences. Such an organization is characterized by the lack of means for diagnosing the personnel situation, assessing labor and personnel, forecasting personnel needs, etc. At best, the personnel process consists of monitoring negative manifestations in working with personnel, the causes and situation of the development of problems: the emergence of conflicts, the lack of qualified labor, the lack of motivation to work. Personnel services do not have a holistic program for forecasting personnel development. In modern conditions of labor market development, increasing employer requirements for employee competencies, demographic aging of the workforce and an increase in the proportion of people who received vocational education several decades ago, as a result of which their competencies do not meet modern requirements; the development of existing and the emergence of new technologies that require new knowledge and skills of employees, personnel policy in the country must undergo significant changes. Personnel processes and services should be based on substantiated programs for the development of the organization, industry and relevant target personnel programs that take into account short-term and medium-term forecasts of personnel needs, the development of the personnel situation; have the means to influence it. Personnel programs

should contain tasks for personnel development, including: measures to adapt the existing labor potential to new requirements provided for by the new strategy of the organization; a new, adequate strategy, concept of job creation and a system of measures for its implementation; measures to anticipate those changes that are provided for by the strategies of the enterprise (organization). Personnel work and processes should acquire a systematic nature, which implies the presence, interconnection and interdependence of all aspects of personnel management, its continuity.

It is advisable to avoid an exclusively technical, resource approach to personnel as an important factor of production, and to treat them as a social component of the organization's activities, since the full formation and restoration of labor potential depends on the social environment, and this, in turn, is a function of the efficiency of economic activity.

When carrying out strategic planning of personnel work, it is important to: determine the real need for personnel by stages of the strategic period; establish the availability of personnel in terms of qualitative parameters and their possible predicted changes in the strategic period (retirement, leaving for service in the army, for training, migration departure, etc.); identify the shortage of personnel in terms of their qualitative parameters by stages of the strategic period, including taking into account the need for new specialists in accordance with the expected strategic changes at the enterprise (in the organization); determine the sources of covering the shortage of personnel by years of the strategic period and in terms of qualitative and qualification groups (both internal and external sources).

Having assessed the shortage of personnel by category for the years of the strategic period, it is possible to draw up a plan for providing them and carry out their training and retraining in educational institutions in advance, conduct targeted career guidance work in educational institutions, among residents, organize training and retraining of personnel in mass professions on site, etc.

The work of personnel services needs to be radically restructured in accordance with the requirements of a market economy and a specific personnel strategy. Personnel service employees should be selected based on the criteria of having satisfactory knowledge at least in such disciplines as personnel management, economics and production organization, psychology, sociology, law, pedagogy, and have testing skills, computer skills, etc.

The selection, placement and training of managerial personnel and specialists should be carried out with mandatory adherence to the following principles: select personnel based on business (competence, professionalism, organizational skills), moral-psychological and political qualities, on a democratic basis, with a combination of experienced and young employees, systematically update and consolidate personnel, work with a reserve.

It is necessary to radically restructure career guidance work in the following areas:

adaptation of traditional approaches to modern requirements and the requirements of the new strategy;

introduction of new, adequate time and strategy, forms and methods of career guidance work;

coordination of the efforts of all possible subjects of career guidance.

Improvement of the system of training and retraining of personnel, which should be based on a focus on the strategic needs of the organization, selection "from below" of applicants with existing abilities, continuity, systematicity. There is a pressing need to introduce independent assessment (certification, attestation) of knowledge, skills and abilities of both graduates of educational institutions and employees who have received them in the process of work and require appropriate confirmation through independent attestation services. In general, the system of vocational education and training should be open in nature and be capable of self-development based on new principles oriented to the labor market, decentralization and social partnership.

Improvement of approaches, forms and methods of selection, placement and promotion of personnel in service, patriotism, professionalism, decency - it is in this sequence of principles that personnel selection should be carried out, taking into account the requirements and conditions, which include the consistent implementation of a number of scientific and research, organizational and managerial, political and legislative actions. In particular, selection and placement should be implemented strictly in accordance with the above principles; Selection by business, political and moral-psychological qualities must be supplemented by an assessment of the results of work in the previous position, taking into account moral-psychological characteristics; conduct selection and placement in such a way that the type of personality corresponds as much as possible to the type of environment that is expected, thus taking into account the human factor more; work out the procedure for promotion of personnel of all categories, including mass professions, to stimulate creativity, self-improvement, increase productivity and quality of work.

It is necessary to proceed to career planning. The criteria in this case should be length of service, positive activity in the position held, positive results of certifications. It is necessary to build a new, not a formal, system of personnel certification. Here it is especially important to objectively evaluate the employee and necessarily make decisions based on the results of the certification with moral and material recognition of the best and the application of moral and material penalties up to dismissal for those who do not meet the requirements.

It is necessary to develop its own system of working with the personnel reserve in accordance with the requirements of the strategy.

The state personnel policy is implemented at the national, regional and local levels. The organizational and legal foundations of personnel policy in the public service of Ukraine include: the Constitution of Ukraine [3], the Labor Code of Ukraine; the Laws of Ukraine “On Civil Service” [8], “On Prevention of Corruption” [9], “On Higher Education”, “On Local State Administrations”, “On Local Self-Government in Ukraine” [12], “On Service in Local Self-Government Bodies” [13], “On Purification of Power”; Decrees of the Presi-

dent of Ukraine “On measures to implement the Concept of Administrative Reform in Ukraine” [10], “On measures to improve work with personnel in executive bodies, with heads of enterprises, institutions and organizations”, “On the system of training, retraining, advanced training of civil servants”, “On approval of the program of personnel support for the civil service and the program of personnel support for heads of state enterprises, institutions and organizations”, “On the Comprehensive Program of Training of Civil Servants” [11]. There is also a considerable number of subordinate regulatory legal acts that regulate personnel processes in the civil service. Therefore, it is incorrect to say that there is no regulatory legal support for personnel processes; it is more appropriate to talk about the existing gaps in that significant number of documents, as well as about contradictions and duplications in them.

Thus, the Strategy of State Personnel Policy states that one of the main goals of its implementation is to develop mechanisms for attracting highly qualified specialists, capable graduates of higher educational institutions, to work in the spheres of public administration, and the Resolution of the Committee of Ministers of Ukraine dated July 29, 2009 No. 789 “On Approval of the Procedure for Admission to the Educational and Professional Program for Master's Degree Training in the Specialty "Public Service" in the Field of Knowledge "Public Administration" and Employment of Graduates” does not provide for the involvement of graduates of a higher educational institution in the educational and professional program for master's degree training in the specialty "Public Service" in the field of knowledge "Public Administration". In accordance with clause 10, persons who have a complete higher education, work in state authorities or local self-government bodies, have at least one year of experience in public service or service in local self-government bodies, and are under 45 years of age are accepted for training under a state order. Of course, this contradicts one of the tasks of the Program for Training and Engaging Youth in Civil Service and Service in Local Self-Government Bodies, Creating Conditions for Their Professional Growth – Improving the System for Selecting Talented Youth to Higher Educational Institutions that Train Specialists for Service in Executive Bodies and Local Self-Government Bodies.

The full-time form of Master’s training should provide for the training of gifted youth, graduates of the current year of a higher educational institution under a state order.

As can be seen, some regulatory legal acts do not enshrine the basic provisions of other regulations and are mostly declarative in nature. Also, one of the solutions to this issue may be the opportunity to train bachelors in the field of knowledge “Management and Administration” in specialty 074 “Public Management and Administration” in accordance with the resolution of the Cabinet of Ministers of Ukraine “On Approval of the List of Fields of Knowledge and Specialties in Which Higher Education Applicants are Trained”. This will allow talented young people to join the ranks of public service after four years of training.

Analysis of statistical data indicates that the average number of people admitted to the civil service each year over the past five years is about 15%, while staff turnover is 16% of the total number of civil servants each year [7]. The decision to appoint or refuse to appoint to a civil service position is made based on the results of a competition (or another procedure provided for by current legislation), a special check in accordance with the Law of Ukraine “On Prevention of Corruption” and the results of a check in accordance with the Law of Ukraine “On Cleansing of Power”. The competition allows you to select from a significant number of candidates the most suitable for a specific position, and also helps to understand the gaps in personal professional development and promotes self-improvement of candidates. At the same time, the current state of staffing is characterized by a biased and opaque competitive procedure. It is mainly formal in nature, since it is often announced in order to appoint the “right” candidate to the “right” position within the framework of current legislation. Mostly, the winner of the competition is not always the person who is most suitable for performing the tasks posed by the vacant position, but the “right” candidate.

It should be noted that special attention also needs to be paid to assessing the impact of factors on the implementation of personnel processes in local government bodies (Table 1).

Table 1

Classification of factors that influence the implementation of personnel processes in local government bodies is proposed.

Factors	Content
Physiological	gender; age; health status; cognitive abilities; physical abilities to understand, etc.
Technical and technological	the nature of the tasks being solved; the complexity of the work; technical equipment; the level of use of scientific and technical achievements and traditions, etc.
Structural and organizational	working conditions; the ratio of the number of categories of personnel; the volume of the enterprise; the mode of work; length of service; the qualifications of employees; the level of use of personnel, etc.
Socio-economic	material incentives; insurance; social benefits; standard of living and others.
Socio-psychological	moral climate in the team; psychophysiological state of the employee; status and recognition; organizational culture of the organization; gratitude; prospects for promotion, etc.
Territorial and situational	location of the organization; time spent on the road from home to work; level of competition; inflation; unemployment; income differentiation.

Thus, based on positive foreign experience adapted to the requirements of our state, it is necessary to professionalize public servants, improve selection for the civil service along with decent working conditions and social, material and technical support. Given the fixed payroll of state authorities and the socio-economic situation of the state, at the same time, salaries cannot increase significantly. And it is in such situations that managers should focus on non-material methods to motivate employees.

The main problems and shortcomings of organizing labor motivation in government agencies can also include: the lack of dependence of career growth on the results of training or advanced training and a clear career process, the existence of a threat of dismissal from a position as a result of a change in the ruling elite, low social status and prestige of the title of civil servant.

In addition, the mechanisms for attracting competent employees to government agencies and their motivation need to be improved. Increasingly, scientific publications reflect the idea of the need to assess not only knowledge (when entering and completing civil service) but also individual psychological characteristics of civil servants. However, no regulatory document specifies who and by what means will determine the suitability of candidates or the compliance of individual psychological characteristics of a candidate for public service with the requirements of professional and official activity in government bodies. It should be noted that both a candidate for a civil servant position and an employee of a government body during their professional activity should be assessed not as a carrier of professional knowledge and skills, but as a person, a carrier of knowledge, skills and abilities necessary for effective activity in this position. This formulation will bring us much closer to considering a civil servant not as a "cog of public administration", but as a professional who provides quality services to citizens in accordance with EU standards.

The Law of Ukraine "On Civil Service" [8] is capable of resolving these problematic issues. According to this document, entry into the civil service is carried out by appointing a citizen of Ukraine to a civil service position based on the results of a competition, which should be carried out taking into account the level of professional competence, personal qualities and achievements of candidates for a vacant position. It should be noted that it is fundamental in implementing the expected civil service reform and is aimed at ensuring the development of the public service. Of course, this will be impossible without the development of effective subordinate regulatory legal acts in accordance

with the new legislation.

However, the development of subordinate regulatory legal acts in accordance with the new Law of Ukraine "On Civil Service" [8] should be based on a systematic approach to the selection, placement and training of personnel based on consideration of professional activity and characteristics of the person and be based on the principles of civil service (rule of law, legality, professionalism, integrity, efficiency, ensuring equal access to civil service, political impartiality, transparency, stability).

Therefore, this is possible when developing a regulatory document that is able to characterize and guide personnel processes in the civil service. This regulatory document must contain clearly defined criteria for each of the positions in state authorities. These same criteria should be guided by training, retraining and advanced training, as well as in the process of annual evaluation of civil servants' activities. A person selected for a specific position must clearly know what he or she is expected to do and what to expect during his or her professional activity, what indicators of his or her work will be evaluated, and what his or her education, training, and retraining will be aimed at. A competency-based approach should be the basis for developing these assessment criteria. The professional standard of the civil service must regulate regulatory requirements for civil servants, setting a system of professional competencies that allow determining the degree of compliance of the employee with the requirements of professional activity and the requirements of society.

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MEDICAL SCIENCES

AI-SUPPORTED DIGITAL HEALTH LITERACY: A CONCEPTUAL FRAMEWORK FOR HEALTHCARE PROFESSIONALS

Gunaydin S.
Balikesir University, Lecturer
DOI: 10.5281/zenodo.21095273

ABSTRACT

Digital health transformation requires healthcare professionals not only to use digital tools but also to evaluate the data produced by these tools and Artificial Intelligent (AI)-supported outputs accurately, safely, and ethically. This study aims to reveal how the concept of digital health literacy can be restructured in the age of AI. Accordingly, studies published between 2015 and 2026 in the Scopus, Web of Science, PubMed, and ERIC databases were searched using a scoping review approach. A total of 600 studies were assessed, 578 unique studies were examined, and 30 studies were included in the core analysis pool. As a result of the thematic synthesis, AI-supported Digital Learning Literacy was identified as a multilayered structure consisting of five domains: digital health systems literacy, AI literacy, data and information literacy, critical evaluation and use of decision support, and ethics, security, and privacy. The findings show that the ability to use digital systems is no longer sufficient for healthcare professionals; rather, they need to evaluate AI-generated outputs, the reliability of data, ethical risks, and their impact on clinical decision-making processes together. The AI-supported Digital Health Literacy framework developed in this study contributes to positioning healthcare professionals as conscious users, critical evaluators, and ethical decision-makers in digital and AI-supported healthcare services.

Keywords: Digital health literacy, AI literacy, healthcare professionals, digital health competencies, scope review.

1. Introduction

Over the past decade, rapid and significant developments in digital technology have made a substantial transformation necessary in the field of healthcare. Technological advances such as electronic health records, big data analytics, clinical decision support systems, AI-supported diagnostic systems, and the integration of wearable Technologies into health systems have become visible within the scope of digital health [1]. The World Health Organization [2] defines digital health as the field of knowledge and practice associated with the development and use of digital Technologies to improve health. Digital health is known to offer several advantages, including providing patients with better and more direct information, supporting healthcare professionals in the diagnosis and treatment of patients, enabling verifiable and searchable records of health data such as births and deaths, and providing health managers with operational and strategic information [3]. However, digital health transformation should not be understood merely as a transformation of technological infrastructure; rather, new competencies related to digital health need to be developed [4].

Although core digital competency categories for healthcare professionals have been classified through different approaches in the literature [4; 5; 6; 7], they generally appear to constitute a multidimensional structure, particularly including digital health literacy, data management, and mobile application use from the foundation of digital health competencies; however, electronic health records, data documentation, and clinical decision support systems also directly enhance the quality of patient care through the large-scale data they provide [5; 6]. Nevertheless, the use of big data raises important questions regarding who owns the collected data, who controls and manages it, and how data privacy can be ensured [3]. These issues become particularly important when AI-based Technologies are used, indicating that digital health competencies need to be addressed from a broader and more complex perspective.

AI-supported applications are already being used in many healthcare processes, including risk scoring, image interpretation, clinical decision support systems, and the summarization of health records [8]. The growing importance of AI in healthcare has created a need for healthcare professionals to develop a comprehensive understanding of AI Technologies [9]. Although AI systems offer various advantages, they also raise several risks and concerns, including privacy, data security, algorithmic bias, and the need to evaluate ethical and legal implications [10]. From this perspective, it is critically important for healthcare professionals to possess not only technical knowledge but also the competence to understand the ethical implications of AI, its role in decision-making processes, and its limitations [8; 11]. In this context, AI literacy among healthcare professionals should be regarded as a necessity.

Long & Magerko [12] defines AI literacy as a set of competencies enables individuals to critically evaluate AI Technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace. AI literacy is addressed across several dimensions, including understanding the structure and functional of AI technologies, critically evaluating and interpreting AI outputs, and developing ethical awareness in the use of AI [13]. Although different organizations and the broader literature provide general frameworks for AI literacy, it appears that a healthcare-specific AI competency framework has not yet been sufficiently addressed [11]. However, AI literacy is critically important not only for general technology use but also for the safe and effective use of AI applications

thay are becoming increasingly widespread in healthcare services.

As the use of AI Technologies in healthcare continues to expand, the need for and interest in AI-related competencies are expected to increase. Recent studies indicate that, for healthcare professionals, AI literacy is not limited to the ability to use AI technologies; it also includes competencies related to understanding how AI works, recognizing its limitations, evaluating its ethical use, identifying algorithmic biases, and understanding its role in clinical decision-making processes [8; 9; 11]. However, these studies generally address AI literacy as a standalone construct and do not consider it together with digital health literacy.

The acceleration of digital transformation in healthcare and the growing use of AI applications is expanding the competencies expected of healthcare professionals. While conventional Digital Health Literacy (DHL) includes skills such as using digital systems accessing information, evaluating this information, and applying it in relevant decisions, AI-supported digital health systems require additional competencies, including understanding AI Technologies interacting with these systems, and critically appraising the outputs they generate. In this context, healthcare professionals need to draw on these two competency domains simultaneously. Therefore, digital health literacy and AI literacy should not be considered independent domains, but rather complementary competencies within the evolving field of digital health. Accordingly, DHL in the age of AI needs to be reconsidered through broader and more integrated dimensions. This study aims to reinterpret the framework of DHL in the age of AI and to propose a competency framework that healthcare professionals need to develop.

2. Method

This study was designed as a scoping review aimed at developing a conceptual framework for AI-supported DHL by integrating the literature on DHL and AI literacy. The scoping review approach is an appropriate method for mapping the existing literature in a specific research area and for identifying key concepts, types of evidence, trends, and gaps in the literature [14].

The literature search was conducted in the Scopus, PubMed, Web of Science, and ERIC databases. During the search process, the keywords “AI literacy”, “digital health literacy”, “health informatics competencies”, “health data literacy”, and “clinical decision support systems” were combined using Boolean operators (AND, OR, NOT), and the search was filtered accordingly.

Several criteria were used to determine the publications to be included in the study. Accordingly, peer-reviewed studies published between 2015 and 2026, written in Turkish or English, related to the fields of health and education, and considered within the scope of AI literacy or DHL were included in the review. Studies for which the full text could not be accessed, studies focusing solely on AI algorithms, and studies that did not address human competencies were excluded.

The studies identified through the search were first screened at the title and abstract level. After duplicate records were removed, a preliminary assessment was conducted in accordance with the inclusion and exclusion criteria. At this stage, studies relevant to the aim of the research were identified, and 30 studies that directly contributed to the domains of AI literacy, digital health literacy, digital health competencies, health informatics, data literacy, and ethics-security were included in the core analysis pool. The studies in the core analysis pool were then examined at the full-text level, and the extracted data were analyzed using a thematic synthesis approach to develop the AI-supported DHL framework. Since this study did not involve data collection from human participants, ethics committee approval was not required.

3. Findings

As a result of the literature search, a total of 600 studies retrieved from the Scopus, Web of Science, PubMed, and ERIC databases were assessed. The first 10 studies from each database, ranked by relevance, were included in the analysis pool. Following the preliminary assessment conducted at the title and abstract level, 154 studies were classified as included, 95 as pending, and 338 as excluded (Table 1).

Table 1.

Distribution of Records by Database

Database	**Number of records retrieved through the search**	**Number of records assessed**
Scopus	1473	150
Web of Science	1270	150
PubMed	472	150
ERIC	435	150
Toplam	3650	600

Among the 600 records assessed, records with identical titles were checked, and 22 duplicate records were removed from the review pool. As a result, 578 studies were screened at the title and abstract level. Following the preliminary assessment (Table 2), 145 studies were marked as “included” because they were directly related to the aim of the study, 95 studies were marked as “pending” because they required full-text review, and 338 studies were marked as “excluded” because they did not meet research criteria. The excluded studies generally focused only on the technical aspects of artificial intelligence and were not related to literacy.

Table 2.

Results of the Preliminary Assessment at the Title and Abstract Level After Duplicate Removal

Preliminary assessment status	**Number of records**
Total number of studies assessed	600
Duplicate studies	22
Unique studies	578
Studies labelled as included	145
Studies labelled as pending	95
Excluded studies	338

As a result of the preliminary assessment conducted based on titles and abstracts, 145 studies were found to be relevant to the research. However, 30 studies that were considered to provide the strongest contribution to the framework intended to be developed were selected for the core analysis pool based on specific selection criteria (Table 3). In this regard, it can be stated that 145 studies constituted the screening pool, whereas the full-text review was conducted within the scope of the 30 core studies, and the findings were synthesized based on the studies in this core group.

Table 3.

Selection Criteria for Studies Included in the Core Analysis Pool

Selection criterion	**Description**
Direct relevance to the research topic	The study was related to AI literacy, digital health literacy, health informatics competencies, health data literacy, or clinical decision support systems.
Conceptual contribution	The study presented a framework, model, competency domain, scale dimension, or education structure.
Health context	The study was addressed in the context of healthcare professionals, health students, health informatics, or healthcare services.
Focus on human competencies	The study included dimensions related to human skills, literacy education, use, decision-making, or ethical evaluation, rather than focusing solely on technical algorithms.
Contribution to framework development	The study could be associated with at least one of the domains of the AI-supported DHL framework.

When the studies included in the core analysis pool were examined, they were found to concentrate on interrelated areas, including digital health literacy, digital health competencies, AI literacy in healthcare, eHealth literacy, health informatics competencies, and digital competencies in clinical practice. These studies provided the basis for structuring the AI-supported DHL framework under the domains of digital health systems use, AI literacy, data and information literacy, critical evaluation, and ethics-security. The main characteristics of the studies included in the core analysis pool and their contributions to the AI-supported DHL framework are presented in Table 4.

Table 4.

Studies Included in the Core Analysis Pool and Their Contributions to the AI-supported DHL Framework

No	**Study**	**Study type**	**Focus**	**Contribution to the AI supported DHL framework**
1	Kim et. al. (2022) *Fundamentals of digital health literacy*	Scoping review	Core competencies of digital health literacy	Supports the traditional literacy, information literacy, media literacy, technology literacy, health literacy, and socioecological dimensions of DHL.
2	Tumuhimbise et al. (2025) *Enablers and challenges of integrating digital health into medical education curricula*	Scoping review	Integration of digital health into medical education curricula	Explains the integration of DHL into the education of healthcare professionals, including implementation barriers and facilitators.
3	Tudor Car et al. (2021) *Digital health training programs for medical students*	Scoping review	Digital health training programs for medical students	Show that digital health training programs re mostly elective, focused on a single domain, and limited in terms of assessment.
4	Brørs et al. (2023) *Among hospital health care providers*	Systematic review	eHealth literacy among hospital healthcare providers	Indicates that eHealth literacy should be addressed through the di-

				mension of individual skills, interaction with the system, and Access to the system.
5	Mainz et al. (2024) *Measuring the digital competence of health professionals*	Scoping review	Measurement of digital competence among health professionals	Shows that digital competence is a multidimensional construct consisting of technical, methodological, social, and personal dimensions.
6	Car et al. (2025) *The digital health competencies in medical education framework*	Delphi-based consensus study	Digital health competency framework	Presents a comprehensive digital health competency framework that includes professionalism, patient and population health, health information systems, and health data science.
7	Jimenes et al. (2020) *Digital health competencies for primary healthcare professionals*	Scoping review	Digital health competencies for primary healthcare professionals	Supports the need for competencies related to electronic health records, medical informatics, information technologies, and digital health education.
8	Nazeha et al. (2020) *A Digitally competent health workforce*	Scoping review	Digital competency frameworks for the healthcare workforce	Supports the dimensions of basic information technologies, health information management, digital communication, ethical and legal requirements, data security, and privacy.
9	Ferreira and Magalhaes (2026) *Instruments to assess the digital health competencies of healthcare professionals*	Scoping review	Instruments for assessing digital health competencies	Shows that multidimensional and psychometrically strong instruments for measuring digital health competencies are limited.
10	Longhini et al. (2022) *Digital health competencies among healthcare professionals*	Systematic review	Digital health competencies among healthcare professionals	Supports eHealth literacy, use of digital technologies, digital health knowledge, and psychological-emotional dimensions among healthcare professionals.
11	Özatkan and Şenel Tekin (2026) *Determinants of digital health literacy of healthcare professionals*	Systematic review	Determinants of digital health literacy among healthcare professionals	Identifies determinants of DHL such as educational level, professional experience, access to digital infrastructure, and technological competence.
12	Ye et al. (2026) *Exploring the status and influencing factors of nurses' digital health literacy*	Scoping review	Digital health literacy among nurses	Classifies nurses' digital health literacy levels, measurement tools, and influencing factors at individual, interpersonal, and organizational levels.
13	Ng et al. (2023) *Artificial intelligence education: An evidence-based medicine approach*	Conceptual /perspective article	Artificial intelligence education for healthcare professionals	Relates AI literacy to evidence-based medicine and clinical decision-making by classifying healthcare professionals as AI users, translators, and developers.
14	Malerbi et al. (2023) *Digital education for the deployment of artificial intelligence in health care*	Viewpoint	Digital education for AI applications in healthcare	Emphasizes that the safe implementation of AI requires education on the fundamentals of machine learning, dataset evaluation, clinical workflow, bias control, and ethical-legal dimensions.
15	El Arab et al. (2025) *Artificial intelligence in nursing*	Systematic review	AI attitudes, literacy, readiness, and adoption intention among nurses	Addresses AI literacy, self-efficacy, attitudes, anxiety, ethical/privacy concerns, and institutional support factors in an integrated manner.

16	Patel et al. (2026) *AI literacy among healthcare professionals and students in the Americas*	Viewpoint	AI literacy for healthcare professionals and students	Discusses AI literacy in relation to medical education, clinical decision support, regional inequalities, and health equity.
17	Buchgraber-Schnalzer et al. (2025) *cMOOC recommendations to enhance AI literacy among healthcare professionals*	Educational design/ experience report	Online AI literacy education for healthcare professionals	Shows that AI literacy can be enhanced through online learning environments and should be supported by ethical and legal discussions.
18	Uluğ et al. (2025) *Adaptation of the artificial intelligence literacy scale into Turkish*	Scale adaptation/ cross-sectional study	Turkish AI literacy scale	Provides a valid and reliable measurement tool for assessing AI literacy in the Turkish context.
19	Ali and Shaban (2026) *AI literacy in nursing education*	Mixed-methods study	AI literacy and ethical awareness in nursing education	Examines AI literacy, ethical awareness, and readiness for AI integration among nursing faculty members.
20	Çoban and Beydağ (2026) *Surgical nurses' artificial intelligence literacy and readiness levels*	Descriptive cross-sectional study	AI literacy and medical AI readiness among surgical nurses	Shows a strong positive relationship between AI literacy and medical AI readiness.
21	Kayser et al. (2022) *Health professionals' eHealth literacy and system experience before and after EHR Implementation*	Longitudinal study	eHealth literacy before and after EHR implementation	Demonstrates the importance of eHealth literacy, system experience, ease of use, and trust in the adoption of EHR systems.
22	Mather et al. (2022) *eHealth literacy of Australian undergraduate health profession students*	Descriptive cross-sectional study	eHealth literacy among undergraduate health profession students	Shows that digital health skills should be integrated into curricula health professions and that data security concerns are important.
23	Jin et al. (2026) *Mapping factors associated with nurses' attitudes toward artificial intelligence*	Scoping view	Factors influencing nurses' attitudes toward artificial intelligence	Classifies attitudes toward AI under demographic, cognitive, affective, behavioral, and external factors.
24	Kontodimopoulos et al. (2026) *Digital skills and readiness of Greek nurses for AI adoption*	Cross-sectional study	Digital skills and readiness for AI adoption among nurses	Shows a gap between general digital skills and readiness for AI, indicating the need for target AI education
25	Loutfy et al. (2026) *Digital proficiency: eHealth literacy and informatics competencies among nursing students*	Cross-sectional study	eHealth literacy and informatics competencies among nursing students	Reveals the relationship between eHealth literacy and nursing informatics competencies.
26	Moafa et al. (2026) *Nurses digital competency and test performance*	Cross-sectional study	Digital competency and task performance among nurses	Shows that digital competency is associated with job performance and work engagement.
27	Mikkonen et al. (2026) *Digital health competence among healthcare*	International cross-sectional cluster analysis	Digital health competence profiles among healthcare professionals	Classifies healthcare professionals' digital health competencies into profiles ranging from beginner to advanced levels.

	professionals across 19 countries and regions			
28	Stock et al. (2026) *Digital competencies of health professionals: German translation and content validation of digihealthcom and digicomlnf*	Translation and content validity study	Adaptation of digital health competency assessment instruments	Shows that the DigiHealthCom and DigiComLnf instruments can be used to assess individual and organizational digital competencies.
29	D'Agostino et al. (2026) *Measurement properties of instruments assessing digital competence in nursing*	Systematic review	Instruments for measuring digital competence in nursing	Evaluates the psychometric properties of instruments measuring nursing informatics, digital health, and information and communication technology competencies.
30	Lee et al. (2023) *Evaluating digital competencies for pharmacists*	Qualitative study	Digital competencies for pharmacists	Shows that profession-specific digital competency frameworks can be used for assessment and educational planning among healthcare professionals.

When the core studies presented in Table 4 are considered together, it becomes evident that AI-supported DHL cannot be addressed as a single area of knowledge or skill. The studies reviewed show that digital health literacy includes competencies such as using digital health systems, working with electronic health records, accessing and evaluating health information in digital environments. In addition, studies on AI literacy reveal that healthcare professionals need to understand the basic functioning of AI systems, question the accuracy of AI-generated outputs, and recognize ethical risks such as algorithmic bias and data security. Accordingly, as a result of the thematic synthesis, the AI-supported DHL framework was structured under five core domains: digital health systems literacy, AI literacy, data and information literacy, critical evaluation and use of decision support, and ethics, security, and privacy.

3.1. Digital Health Systems Literacy

The reviewed studies indicated that one of the core domains of AI-supported DHL is the competency to use digital health systems effectively. This domain includes competencies related to electronic health records, health information systems, telehealth applications, digital communication tools, and the management of digital patient data [5; 15; 16]. In addition, findings on the implementation of EHR systems show that not only technical Access but also system experience, ease of use, trust, and the level of eHealth literacy are influential in healthcare professionals' adoption of digital systems [17]. Therefore, digital health systems literacy was considered a foundational competency domain within the AI-supported DHL framework, upon which the other domains are built.

3.2 AI Literacy

The reviewed studies indicated that the second core domain of AI-supported DHL is AI literacy. This domain includes healthcare professionals' understanding of basic operating logic of AI systems, their appropriate use of AI-supported tools, and their critical evaluation of the outputs generated by these systems [18; 19]. Studies in the field of healthcare show that AI literacy is not limited to technical knowledge; rather, it also includes dimensions such as ethical awareness, algorithmic bias, data privacy, clinical safety, and human oversight [20; 21]. In addition, studies conducted with nurses and healthcare professionals indicate that as AI literacy increases, readiness for and the tendency to adopt medical AI applications also become stronger [22]. Therefore, AI literacy was considered a core competency domain within the AI-supported DHL framework, enabling healthcare professionals to use AI-supported digital systems safely, ethically, and consciously.

3.3. Data and Information Literacy

The third domain of the AI-supported DHL framework is data and information literacy. This domain includes healthcare professionals' competencies in accessing health information, understanding, managing, and interpreting data, and transforming it into usable knowledge in clinical decision-making processes [23; 24]. The inclusion of health information management, health data science, data security, and informatics competencies as core areas in digital health competency frameworks further strengthens the importance of this domain [15; 16]. Moreover, since the quality, accuracy, and clinical relevance of the data used in AI-supported systems are directly related to the reliability of AI-generated outputs, data and information literacy was considered one of the central components of the AI-supported DHL framework.

3.4. Critical Evaluation and Use of Decision Support

The reviewed studies indicate that another important domain of AI-supported digital health literacy is critical evaluation and the use of decision support. This domain includes healthcare professionals' ability to evaluate the information, recommendations, and outputs obtained from digital and AI-supported systems in

terms of accuracy, reliability, clinical appropriateness, and patient safety, rather than accepting them directly. In studies on AI literacy, technical understanding, critical evaluation, practical application, and ethical awareness are addressed as core components; healthcare professionals' readiness for medical AI is also considered to be related to these components [22; 25]. Similarly, studies on nursing informatics and digital health competencies show that information evaluation, informatics competence, and the ability to critically analyze digital solutions are necessary for digital data to be used in clinical decision-making processes [26; 27; 28]. Therefore, critical evaluation and the use of decision support were considered a core domain within the AI-supported DHL framework, enabling healthcare professionals to use digital and AI-based outputs consciously, safely, and in an evidence-based manner.

3.5. Ethics, Security, and Privacy

The reviewed studies indicate that the final domain of AI-supported DHL is ethics, security, and privacy. This domain includes healthcare professionals' competencies in protecting the confidentiality of patient data in digital health and AI applications, recognizing data security risks, and evaluating ethical issues such as algorithmic bias and data misuse. Studies conducted with health students and healthcare professionals show that the security of online health data, data privacy, and trust in digital systems are integral components of digital health literacy [29; 30]. Studies in the context of AI further demonstrate that ethical awareness, patient safety, algorithmic bias, human oversight, and institutional governance requirements are key determinants in the use of AI in healthcare [20; 21]. Therefore, ethics, security, and privacy were considered a core competency domain within the AI-supported DHL framework, enabling the safe, responsible, and patient-rights-oriented use of digital and AI-based healthcare applications.

When the five domains are considered together, AI-supported DHL appears to be a multidimensional construct that goes beyond the ability to use digital health systems and integrates AI knowledge, data and information management, critical evaluation, ethical sensitivity, and security awareness. This framework is therefore considered a holistic literacy domain that supports healthcare professionals' conscious, safe, and ethical participation in digital and AI-supported healthcare services.

4. Discussion

This study shows that AI-supported DHL cannot be explained solely by the ability to use digital tools; rather, it represents a multilayered competency area that integrates digital health systems, AI literacy, data and information literacy, critical use of decision support, and ethics-security dimensions. This finding is consistent with studies emphasizing that digital health competencies should be addressed beyond technical skills and in relation to information management, communication, ethical responsibility, patient safety, and professional decision-making processes [15; 16; 24].

The findings indicate that having basic knowledge of AI is not sufficient for healthcare professionals to benefit from AI-supported systems. It is also necessary for them to evaluate the operating logic of these systems, their data-based limitations, the reliability of the outputs they generate, and their appropriateness to the clinical context. This is consistent with studies showing that AI education should include not only technical knowledge but also dimensions such as algorithmic bias, data security, ethical awareness, and human oversight [18; 19; 20].

The AI-supported DHL framework developed in this study establishes a conceptual bridge between digital health literacy and AI literacy. Although digital health competencies, eHealth literacy, health informatics, and AI literacy are often addressed as separate domains in the existing literature, the integration of AI with digital healthcare services requires these competencies to be considered together. Therefore, the AI-supported DHL framework indicates that education for healthcare professionals should go beyond tool use and the teaching of basic concepts and should also include practice-oriented competencies such as data literacy, critical evaluation, ethical decision-making, patient privacy, and the safe use of technology.

5. Conclusion

This study shows that DHL needs to be reconsidered in the age of AI. For healthcare professionals, the ability to use digital systems alone is no longer sufficient; they must also be able to evaluate the data produced by these systems, AI-generated outputs, ethical risks, and their impact on clinical decision-making processes together. Therefore, the AI-supported DHL framework proposed in this study indicates that healthcare professionals should take part in AI-supported healthcare services not only as users, but also as conscious evaluators and ethical decision-makers.

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COMPETITIVENESS OF HEALTH TOURISM IN BULGARIA

Sergeeva E.
Doctoral candidate in the Department of Health Management and Health Economics, Faculty of Public Health „Prof. Tzekomir Vodenicharov, MD, DSc", Medical University – Sofia
Popov N.
Professor in the Department of Health Management and Health Economics, Faculty of Public Health „Prof. Tzekomir Vodenicharov, MD, DSc", Medical University – Sofia
ORCID ID 0000-0001-6154-4253
Mihaylov R.
Assoc. professor in "Yordanka Filaretova" Medical College, Medical University - Sofia
ORCID ID 0000-0001-7786-266X
DOI: 10.5281/zenodo.21095301

ABSTRACT

The present study is dedicated to the competitiveness of health tourism in Bulgaria in the context of the dynamically developing global and European market for health-tourism services. The research aims to identify its main competitors and to formulate guidelines for the development of the sector.

The methodological approach includes analysis of specialized literature, regulatory documents and market data, as well as a survey conducted in the period February–April 2026 among 453 respondents.

The results show that Bulgaria has significant potential for the development of health tourism, based on a rich resource of mineral waters, favorable natural conditions, traditions in balneotherapy, and opportunities to combine medical, rehabilitation and tourism services. However, the country lags behind its main competitors in terms of international recognition, marketing, infrastructure, accreditation, digitalization and institutional coordination.

It has been established that the main users of health tourism in Bulgaria are citizens of European countries, mostly from Germany, Greece and Romania, while Turkey stands out as the leading regional competitor. The analysis identifies key barriers to the development of the sector: insufficient funding, weak international visibility, poor transport connectivity, a limited number of international certifications, seasonality, digital underdevelopment and insufficient coordination between the sectors of healthcare, tourism and public administration.

Keywords: Health tourism, medical tourism, balneotourism, SPA and wellness, competition and market of health tourism services.

INTRODUCTION

Health tourism is among the most dynamically developing segments of tourism because it combines prevention, treatment, rehabilitation and wellness into an integrated consumer experience. Bulgaria has mineral springs, a favorable climate, traditions in balneotherapy and the opportunity to combine medical services with natural and tourism resources. The country ranks first in Europe in terms of number and diversity of mineral springs, with 102 resorts and over 600 mineral water sources, yet it significantly lags behind regional competitors in marketing, infrastructure and institutional organization. The development of the sector has the potential to enhance the country's competitiveness, attract international visitors and stimulate the regional economy and employment. Alongside this potential, problems emerge in organization, management, financing, coordination and international popularity, which necessitate an in-depth study and practical recommendations. Health tourism in Bulgaria is at a crossroads between huge untapped potential and acute competitive challenges. The global medical tourism market was valued at USD 47–55 billion in 2024 and is expected to reach USD 221 billion by 2033 with a CAGR of 18.8%, representing a strategic window for Bulgaria's positioning.

AIM, OBJECTIVES AND METHODS

The aim of this study is, on the basis of an in-depth analysis of available literature and a proprietary survey, to assess the position of Bulgaria on the European market of health tourism services, to determine its main competitors and to formulate recommendations for development.

To achieve this aim, we set the following main objectives:

1. To analyze the state and position of Bulgaria on the market of health tourism services.
2. To identify the main competitors, their advantages and disadvantages.
3. Based on the analysis, to formulate recommendations for the development of health tourism in Bulgaria.

ANALYSIS

In the period February–April 2026 a survey was conducted covering 453 respondents – users of health tourism (41.94%), representatives of healthcare facilities (26.93%), local/national administration and students at medical universities and medical colleges. The largest share of respondents are from the capital (41.06%), followed by residents of towns (36.20%) and villages and regional centers. Part of the questions in the survey address the position of Bulgaria on the market of health tourism services, the competitive environment and the main tourism flows.

Fig. 1. From which countries do most users of health tourism in Bulgaria come?

As can be seen from Fig. 1, the respondents indicate that the main users of health tourism in Bulgaria (72.41%) are citizens of European countries, primarily from Germany, Greece and Romania. This is entirely understandable – German citizens are traditional tourists for Bulgaria who have been familiar with and have benefited from Bulgaria's natural and tourism opportunities over the last 60–70 years. Greece and Romania are neighboring countries and the opportunities that Bulgaria offers are well known to them, while their location allows for frequent visits not only for longer stays, but even for short-term weekend trips. In second place (18.98%) are citizens from Russia and the CIS, who constitute a significant but geopolitically risky market. Users of health tourism services from the Middle East are few (3.75%), which is a prerequisite for the development of this small but high-potential market.

Turkey is the main competitor, identified by 19.23% of respondents. It emerges as the dominant regional competitor. The Turkish medical tourism market was valued at USD 1.89 billion for 2023 and is expected to reach USD 3.48 billion by 2029 with a CAGR of 10.51%. As of 2026, its market value is already estimated at USD 4.60 billion, with a forecast of USD 12.01 billion by 2033.

Turkey attracts patients with medical costs 70–90% lower than those in Western Europe, North America and the United Kingdom. The country has numerous JCI-accredited hospitals and clinics and active government support with investments of USD 50 billion in public healthcare for 2024. Turkey handles over 1.2 million international dental patients per year – about four times more than Hungary, and the country itself reported 701,046 health tourists only for 2019.

According to the respondents, the main competitors from the EU are Germany (6.59%), Italy (6.04%), Austria (4.40%), Romania (4.40%) and the Czech Republic (3.30%), which is formed on the basis of personal observation/experience and professional knowledge of the surveyed individuals. This largely overlaps with other studies of ours, according to which the main competitors from the EU are countries such as Hungary, the Czech Republic, Austria and Slovenia. Hungary has built an international brand "Land of Spas" and "City of Baths" (Budapest), with a focus on balneotherapy, wellness hotels, historic baths and dental clinics. German patients have remained a dominant market for Hungary for decades, and the country positions itself within the EU regulatory framework – a significant advantage over Turkey. The Czech Republic, Austria and Slovenia are identified as direct competitors of Hungary in balneotherapy and SPA tourism. EU health tourism accounts for around 5% of total tourism in the EU and contributes approximately 0.3% to the European economy.

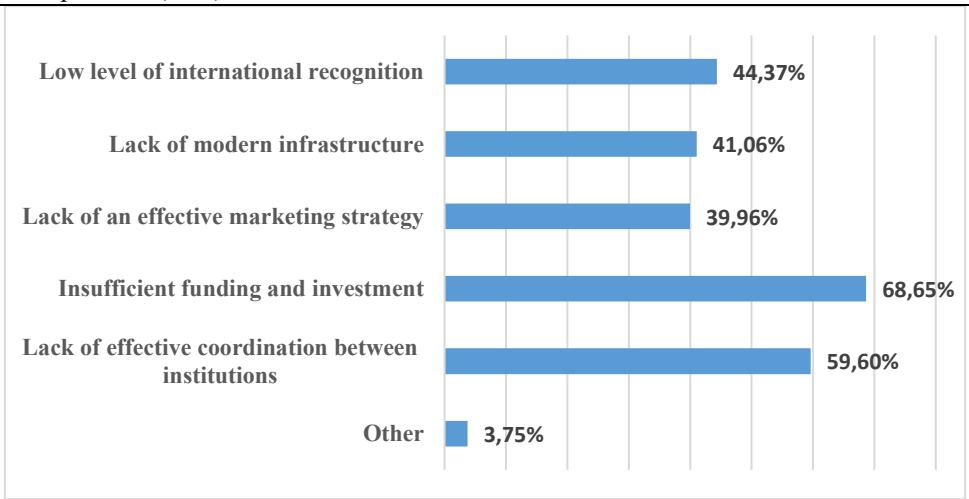

Fig. 2. Main obstacles to the development of health tourism in Bulgaria

Figure 2 presents the answers to the question "In your opinion, what are the main obstacles to the development of health tourism in Bulgaria?" The question is multiple-choice – respondents can give more than one answer and therefore the total number of responses exceeds 100%.

We can present the main problems and challenges in three aspects – structural, market-related and institutional.

Structural challenges

Insufficient international visibility and marketing is Bulgaria's critical weakness. A significant share (44.37%) of respondents point to low international popularity as an obstacle to the development of health tourism in the country. In Turkey we observe the exact opposite. There, the state invests aggressively in marketing and advertising for tourism development with the participation of government agencies and global partnerships.

Weak transport connectivity around balneo-destinations is directly identified by the chair of BUBSPA, Siika Katsarova, as a major problem. The EBRD strategy for Bulgaria 2025–2030 confirms that road infrastructure is still insufficient and the railway network requires substantial upgrades.

Respondents point to insufficient funding (68.65%) as a major obstacle to development. At the same time, Turkey alone allocated USD 50 billion for healthcare in 2024, with this large investment aimed at stimulating the development of modern medical infrastructure that will attract international patients and develop the country's medical tourism market.

Limited JCI accreditation and international certifications reduces foreign patients' trust. The shortage of medical and rehabilitation professionals is directly mentioned by BUBSPA as a significant problem, although the country is among the leading in the EU in number of physicians and dentists per 100,000 inhabitants.

Market challenges

Seasonality – despite the potential for year-round tourism, actual utilization remains uneven. Scientific literature confirms that increasing the share of health tourism can reduce seasonality. Hungary has succeeded in reducing seasonal fluctuations through investments in SPA destinations.

Digital underdevelopment in marketing and online presence. A study of digital tourism platforms in Bulgaria identifies "weak digital presence in smaller municipalities" and "poor integration with social networks".

Price competition with Turkey: Turkey offers dental implants at EUR 400–800 compared to EUR 600–1,000 in Hungary, but price is only one of the factors. In choosing a destination for health tourism, costs of transport (flights), hotels and living expenses are important, as well as the possibility of combining treatment with leisure and language support (for example, in Turkey Smile & Holiday offers coordination in six languages). Bulgaria competes primarily on price, but Turkey offers lower prices with more modern infrastructure.

The exclusion of private medical SPA centers from contracts with the National Health Insurance Fund (NHIF) and the lack of funding from the National Social Security Institute places the private sector at a disadvantage compared to subsidized competitors.

Institutional challenges

Lack of coordination between healthcare, tourism and public administration – 59.60% of respondents indicate it as a major barrier. Turkey's successful model includes a single government agency coordinating all aspects of medical tourism.

Regulatory framework – despite the existence of Ordinance No. 04-14 of 2019 for the certification of balneotherapy centers, changes in the regulatory framework lag behind market dynamics.

On the basis of the analysis we can formulate the following **main directions** aimed at increasing competitiveness and developing health tourism in Bulgaria.

Differentiation from Turkey

Bulgaria should not compete head-on with Turkey on price, but should build a different market position based on:

- EU security and regulatory framework – for Western European patients, especially German and Austrian, EU membership and GDPR are decisive advantages.

- Natural authenticity and balneotherapy – positioning as a "green, authentic alternative" with an emphasis on mineral springs and nature, unlike Turkey, which is oriented towards medical procedures.
- Integrated wellness packages – combining medical procedures with ecotourism, mountain nature and rich historical heritage.
- Year-round destination – unlike Turkey with a focus on seaside and urban tourism, Bulgaria can offer a ski-SPA winter product (Bansko), a mountain summer product and marine rehabilitation.

Competitive strategies against EU destinations (Hungary, Czech Republic, Austria, etc.)

Bulgaria should:

- Brand its balneo-destinations by analogy with Budapest ("City of Baths") and Karlovy Vary – developing the concept "Velingrad – the SPA capital of the Balkans".
- Invest in accreditation – large-scale introduction of JCI, ISO and European medical certifications to increase trust.
- Attract German and Austrian markets – there are already successful contracts with German health funds, which are a ready channel for scaling.
- Integrate wellness innovations – digital detox, yoga retreats, meditation and sports tourism with traditional balneotherapy services.

Institutional reforms

- A unified coordination structure following Turkey's model – a government agency combining health, tourism and investment competencies.
- Inclusion of private medical SPA centers in NHIF and NSSI schemes to reduce the financial burden and increase accessibility.
- Simplification of licensing and certification for health-tourism facilities.
- Strategic partnerships with Destination Management Organizations (DMOs), following models successfully applied in other tourism regions.

Marketing and digitalization

- Participation in 27 international tourism fairs – the plans of the Ministry of Tourism for 2025 include presence on key markets, which should be specified with health-tourism content.
- Partnerships with global platforms – National Geographic, BBC, CNN, Google, Meta and Booking.com for targeted health-tourism campaigns.
- A unified digital platform for health tourism with a multilingual interface, facility accreditations and online booking.
- Influencer marketing with a focus on wellness and balneotourism to reach younger audiences (the 31–50 age group is dominant).

Infrastructure investments

- Transport connectivity to balneo-destinations – construction or rehabilitation of roads to Velingrad, Sapareva Banya, Narechenski Bani.
- Modernization of the hotel base – only 3.97% of respondents rate the material base as excellent, which requires attracting foreign investment through incentives and European funds.
- Specialized medical centers for targeted development of medical tourism – eye surgery, dental services, orthopedics and rehabilitation.

Using a new competitive advantage – Schengen and the euro

- Schengen membership eliminates border controls and is already showing a tangible increase in short-term car tourism from neighboring countries.
- The Eurozone (from 1 January 2026) allows tourists to compare prices directly and eliminates currency risk – a key advantage for German and Austrian patients.

CONCLUSION

From the analysis conducted we can conclude that Bulgaria possesses unique competitive advantages – especially in balneology and natural resources – but needs systemic reforms to transform this potential into competitiveness. Health tourism in Bulgaria has real potential to become a strategically important sector with high added value for the national economy, regional development and the international image of the country. The analysis shows that Bulgaria has objective advantages related to natural resources, traditions in balneotherapy and the opportunities to combine treatment, rehabilitation, prevention and tourism experience, but still fails to turn them into a sustainable competitive advantage.

The main reasons for this are related not so much to lack of resources as to insufficient strategic organization, limited international recognition, infrastructure deficits, insufficient digitalization and the absence of a coordinated state policy. In the context of strong competition from Turkey and established European destinations, the future development of health tourism in Bulgaria should be based on clear market positioning, institutional integration, investments in quality and branding, as well as on the creation of innovative and year-round health-tourism products.

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PROFILE OF BLOOD DONORS IN THE CITY OF BURGAS DURING THE PERIOD 2020–2024

Georgieva L.
Doctoral candidate in the Department of Health Management and Health Economics, Faculty of Public Health „Prof. Tzekomir Vodenicharov, MD, DSc", Medical University – Sofia
Zlatanova T.
Professor in the Department of Health Management and Health Economics, Faculty of Public Health „Prof. Tzekomir Vodenicharov, MD, DSc", Medical University – Sofia
ORCID ID 0000-0003-1057-6516
Gonchev V.
Professor in the Department of Internal Medicine, Pharmacology, Pediatrics, Social Medicine, Emergency Medicine, Computer Technologies, Latin Language, University "Professor Dr. Assen Zlatarov"– Burgas
ORCID ID 0000-0003-2740-5406
Mihaylov R.
Assoc. professor in "Yordanka Filaretova" Medical College, Medical University - Sofia
ORCID ID 0000-0001-7786-266X
DOI: 10.5281/zenodo.21095323

ABSTRACT

Blood donation is a fundamental component of modern healthcare systems and ensures the availability of safe blood components for patients. The aim of this study was to analyze the demographic profile of blood donors in Burgas, Bulgaria, during the period 2020–2024.

A retrospective observational study was conducted using data from the Department of Transfusion Hematology in Burgas. Donors were analyzed according to age, sex, and annual dynamics.

The results demonstrated a steady increase in the number of blood donors from 7,671 in 2020 to 9,176 in 2024. The most active donor group was aged 31–40 years. Men accounted for approximately 75–80% of all donors throughout the study period, while women remained significantly underrepresented.

The findings may support the development of regional policies aimed at strengthening voluntary non-remunerated blood donation.

Keywords: blood donation, blood donors, transfusion medicine, public health, demographics, Burgas.

INTRODUCTION

Ensuring an adequate supply of safe blood and blood components remains one of the major challenges facing modern healthcare systems. The World Health Organization identifies voluntary non-remunerated blood donation as the most reliable mechanism for ensuring the safety and sustainability of blood supplies.

In recent years, demographic changes, population aging, and migration processes have significantly affected the available donor pool. Analyzing the profile of blood donors is an important tool for planning transfusion medicine activities and for developing effective policies aimed at recruiting and retaining voluntary blood donors.

AIM

The aim of this study was to analyze the profile of blood donors in the city of Burgas during the period 2020–2024 according to age and sex and to identify the main trends in the development of the donor population.

MATERIALS AND METHODS

A retrospective observational study was conducted using data from the Department of Transfusion Hematology in Burgas for the period 2020–2024. Statistical data on the number of blood donors, categorized by age group and sex, were analyzed.

The following methods were applied:

1. Descriptive statistical analysis;
2. Comparative analysis;
3. Graphical trend analysis;
4. Analysis of the ratio between the number of blood donors and the population.

RESULTS

The analysis revealed a consistent positive trend in the number of blood donors throughout the study period.

The total number of blood donors was as follows:

1. 7,671 in 2020;
2. 6,753 in 2021;
3. 7,720 in 2022;
4. 8,400 in 2023;
5. 9,176 in 2024.

Overall, the data demonstrate a steady increase in donor activity during the study period, with the highest number of blood donors recorded in 2024.

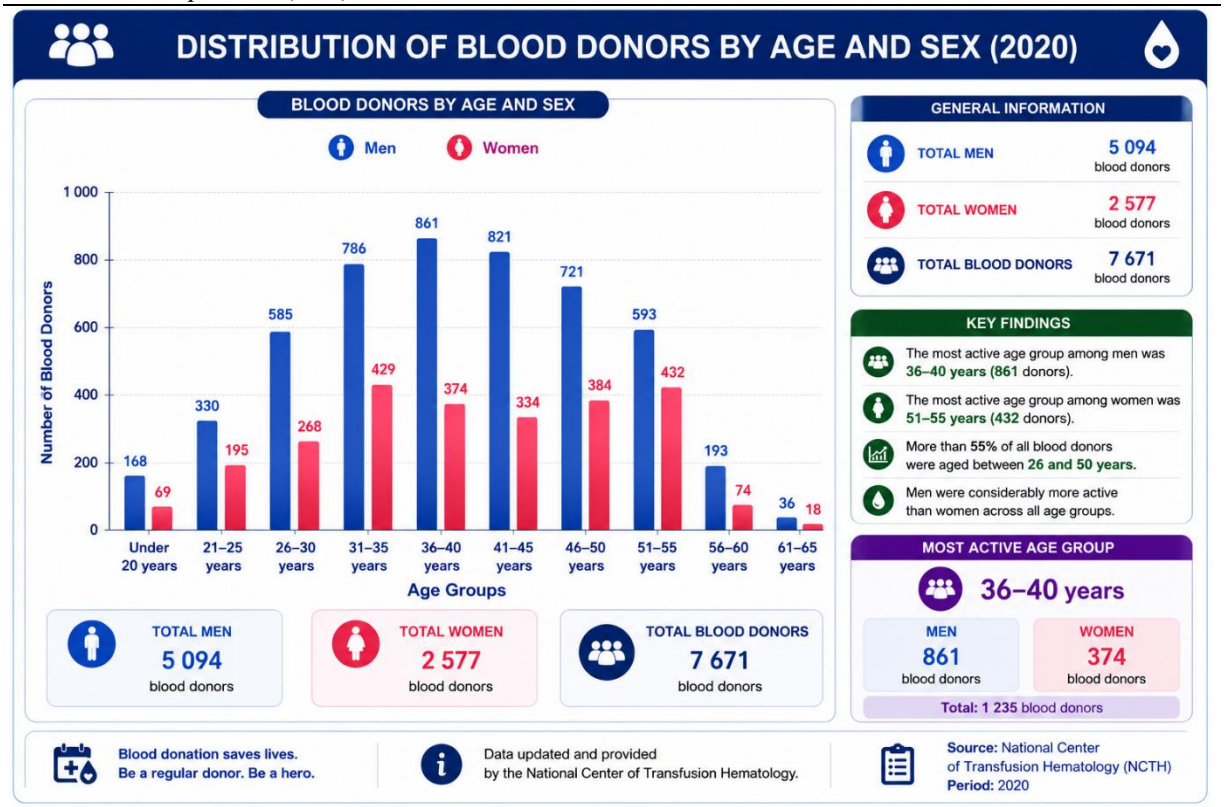


Figure 1

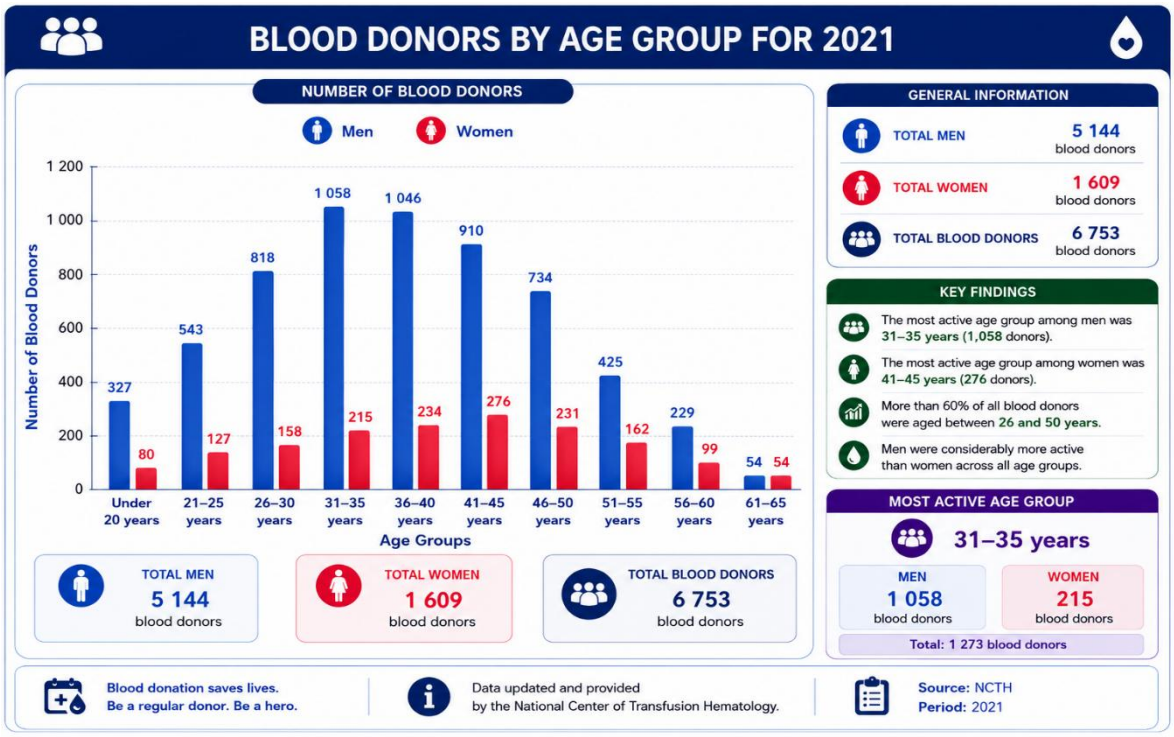
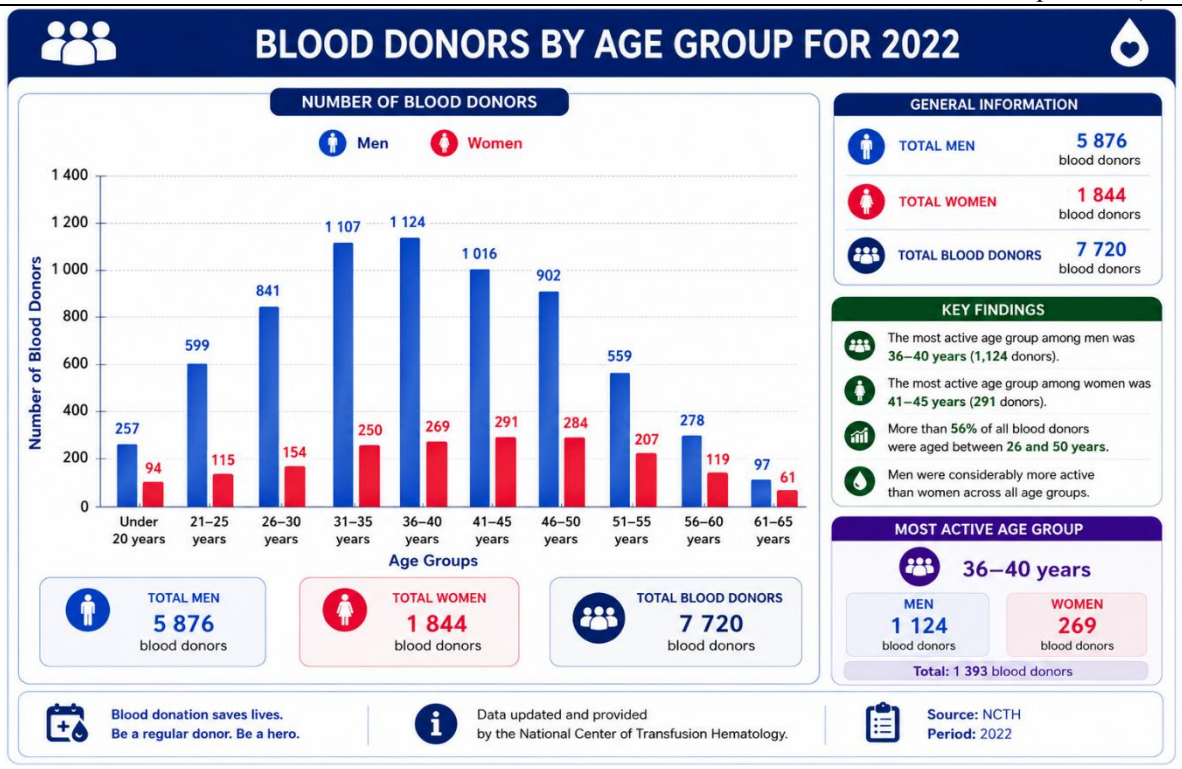


Figure 2



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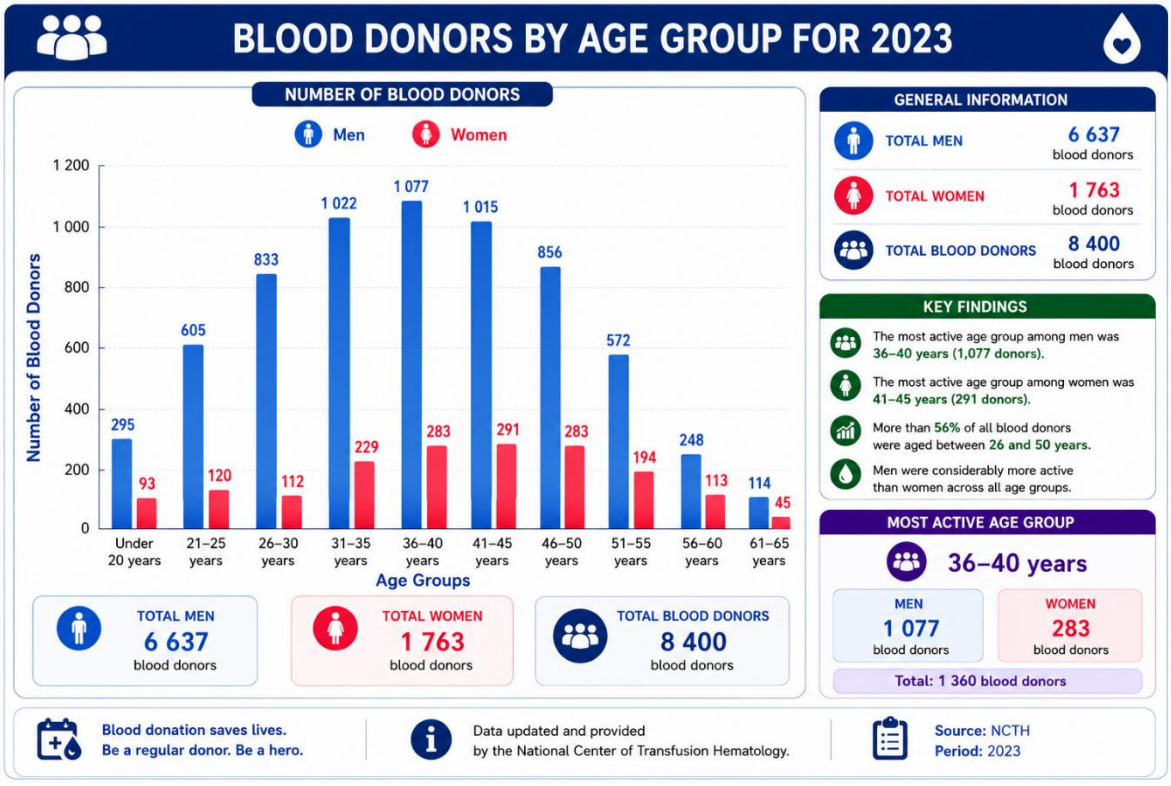

Figure 4

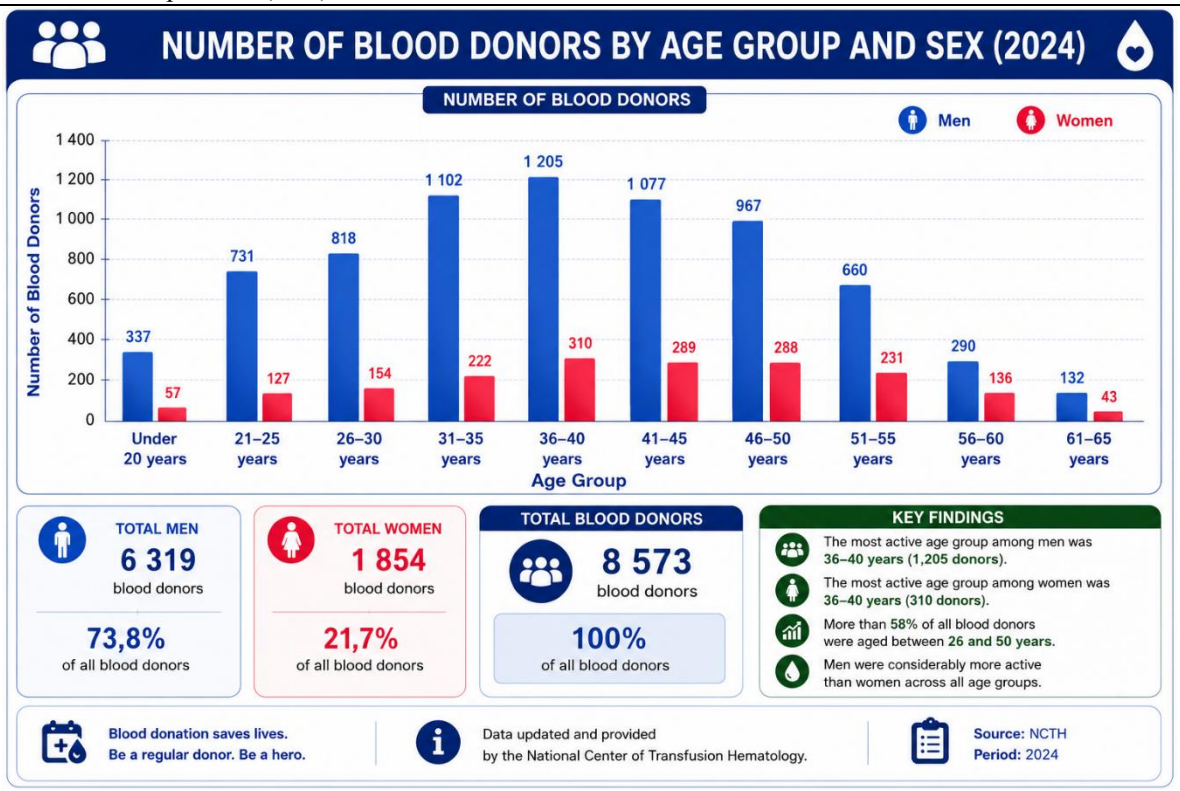

Figure 5

ANALYSIS

Following the period of restrictive measures imposed during the COVID-19 pandemic, a sustained recovery and subsequent increase in donor activity were observed.

The highest donor activity was recorded in the 31–35 and 36–40 years age groups. Throughout the entire study period, these groups constituted the core of the donor population.

A clear predominance of male blood donors was identified. Their relative share ranged between 75% and 80% of all donors, whereas women accounted for approximately one quarter of the donor population.

Among men, a distinct peak was observed in the 31–40 years age range, followed by a gradual decline after the age of 45. In contrast, the distribution among women was more evenly spread, with the highest level of donor activity recorded in the 41–55 years age groups.

The calculations indicate that in 2024 there were approximately 40.77 blood donors per 1,000 working-age residents in Burgas and 23.93 blood donors per 1,000 inhabitants of the total population.

Figures 1–5 illustrate several common trends observed throughout the study period:

1. The total number of blood donors showed a gradual increase over the years, rising from 7,671 in 2020 to 9,176 in 2024.
2. The highest numbers of blood donors were recorded in the 36–40 and 31–35 years age groups.
3. The lowest numbers of blood donors were observed among the oldest age group (61–65 years) and the youngest age group (under 20 years).
4. Men predominated among blood donors, accounting for nearly four times as many donors as women.
5. After the age of 50 years, the number of blood donors declined considerably.

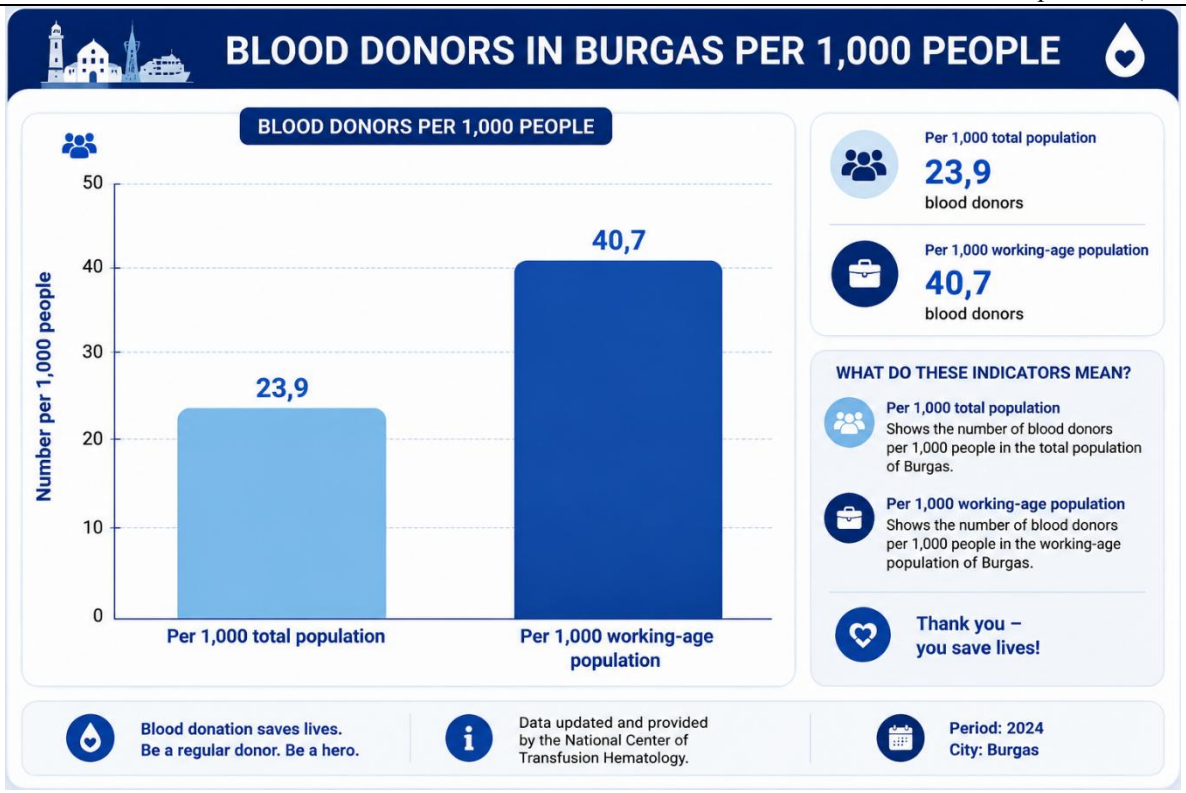
BLOOD DONORS IN BURGAS PER 1,000 PEOPLE
BLOOD DONORS PER 1,000 PEOPLE
Number per 1,000 people
50
40
30
20
10
0
23,9
40,7
Per 1,000 total population
Per 1,000 working-age population
Per 1,000 total population
23,9
blood donors
Per 1,000 working-age population
40,7
blood donors
WHAT DO THESE INDICATORS MEAN?
Per 1,000 total population
Shows the number of blood donors per 1,000 people in the total population of Burgas.
Per 1,000 working-age population
Shows the number of blood donors per 1,000 people in the working-age population of Burgas.
Thank you – you save lives!
Blood donation saves lives. Be a regular donor. Be a hero.
Data updated and provided by the National Center of Transfusion Hematology.
Period: 2024
City: Burgas

Figure 6

The calculations indicate that in 2024 there were approximately 40.77 blood donors per 1,000 working-age residents in Burgas and 23.93 blood donors per 1,000 inhabitants of the total population.

In developed countries, the number of blood donors generally ranges between 33 and 50 per 1,000 population. In developing countries, this figure may fall below 10 donors per 1,000 population, often resulting in shortages of blood and blood components.

The results obtained for Burgas indicate a relatively high level of donor activity, approaching the levels typically reported in developed countries. This finding suggests a stable donor base and a favorable potential for maintaining an adequate blood supply for regional healthcare needs.

DISCUSSION

The results obtained are consistent with published international data regarding the demographic structure of blood donors. In many European countries, men constitute the majority of voluntary blood donors.

The lower participation of women may be explained by a combination of physiological, medical, and social factors. Lower hemoglobin levels, a higher prevalence of iron deficiency, pregnancy, and breastfeeding may limit the ability of women to donate blood regularly. Furthermore, women are more likely to refrain from blood donation due to health-related concerns.

The 31–40 years age group represents the core donor population. This may be attributed to higher levels of social activity, greater professional stability, and better overall health status compared with older age groups.

The relatively low proportion of young donors under the age of 25 highlights the need for more intensive educational and awareness campaigns in schools and universities.

The findings support the need for targeted regional programs aimed at promoting voluntary blood donation and rejuv

LIMITATIONS OF THE STUDY

The present study is limited to data obtained from the Department of Transfusion Hematology in Burgas and does not encompass all potential factors influencing blood donation activity.

The following variables were not analyzed:

1. Educational status;
2. Occupational background;
3. Motivation for blood donation;
4. Frequency of repeat donations.

Future studies may incorporate sociological approaches to provide a more comprehensive analysis of the motivational factors associated with blood donation behavior.

CONCLUSION

During the period 2020–2024, a sustained upward trend in the number of blood donors was observed in the city of Burgas.

The predominant donor profile was a male donor aged between 31 and 40 years.

Women participated in blood donation considerably less frequently, although their proportion remained relatively stable throughout the study period.

The findings highlight the need for targeted measures aimed at attracting young people and increasing female participation in voluntary blood donation.

The results of this study may serve as a basis for the development of regional policies and strategies to ensure the sustainable growth and maintenance of the donor population.

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PEDAGOGICAL SCIENCES

ПОСТРОЕНИЕ ГРАФИКОВ НА ОСНОВЕ ФУНКЦИОНАЛЬНЫХ ЗАВИСИМОСТЕЙ В КУРСЕ ФИЗИКИ

Алиева Д.З.
п.у.ф.д, доцент физического факультета АДПУ

CONSTRUCTION OF GRAPHS BASED ON FUNCTIONAL DEPENDENCIES IN THE PHYSICS COURSE

Aliyeva D.
p.y.f.d., associate professor of physics faculty of ASPU
DOI: 10.5281/zenodo.21095345

АННОТАЦИЯ

Решение графических задач создает основу для формирования у студентов навыков наблюдения за физическими явлениями и процессами, понимания их научно-теоретических основ, систематизации полученных знаний и их применения на практике. Студенты наблюдают физические явления, измеряют определенные физические величины, проводя различные эксперименты, описывают результаты в таблицах и графиках, определяют закономерности между величинами.

ABSTRACT

Solving graphic issues creates a foundation for the formation of students' skills to observe physical phenomena and processes, understand their scientific-theoretical foundations, systematize the acquired knowledge and apply it in practice. Students observe physical phenomena, measure certain physical quantities by conducting various experiments, describe the results in tables and graphs, and determine the regularities between quantities.

Ключевые слова: граф, физическая величина, процесс, математика, функция, графическая задача.

Keywords: graph, physical quantity, process, mathematics, function, graphical problema.

Deep assimilation and memorization of physical phenomena and laws studied during the teaching of physics is organically related to the problem solution related to the relevant discussion. Observations show that applicants who take the physics exam have certain difficulties in solving problems, especially in graphic matters.

The graphical method, which is the basis of mathematics, is used at different stages of teaching physics. Thus, the graph allows to show the characteristics of what is happening, predict the expected result, and visually explain the answer.

Graphs are used in physics to formulate and analyze physical quantities by determining their relationship with other quantities, and to solve problems for the purpose of generalizing and systematizing knowledge.

The analysis of a number of methodical literatures from physics showed that graphical problems can be divided into two large groups:

• Issues related to graph construction

• Issues used to retrieve information from graphs

Issues related to the construction of graphs, in turn, are divided into two types (according to the types of tasks):

• tabular method of determining dependencies

• A functional way of determining dependencies

Tasks for obtaining information from the graph are divided into three types:

• Oral description of processes

• Analytical expression of functional dependency

• Determination of unknown quantities from graphs

Often, when building a graph of the dependence of one quantity on another, some students remember only the appearance of the graph without going into detail why the graph is like this and not otherwise. When enough dependencies are accumulated, they make serious mistakes in the construction of graphs.

The analysis of the answers to the test tasks of the applicants during the entrance exams is very sad. Almost 50% of graduates refused to answer the graphic issues, most of the answers given were wrong. These facts once again confirm that graphic issues should be addressed more in high school. Because such issues, regardless of the type, help to revive physical phenomena, determine the dependence between physical quantities, generalize and systematize their knowledge.

The questions included in the entrance exams are organized on the basis of the school course and are at different difficulty levels. Here, it is envisaged to understand physical laws, processes, concepts, principles and events, to describe the dependencies between physical quantities on a graphic basis, and to solve various types of issues. Those questions include the “Mechanics”, “Molecular Physics”, “Thermodynamics”, “Electrodynamics, “Optika”, “Quantum Physics”, “Atomic and nuclear physics” sections.

In the entrance exam, the following knowledge and skills are checked and evaluated:

1. Understanding and mastering the essence of physical laws and principles;

2. Ability to solve problems of different types and different difficulty levels;

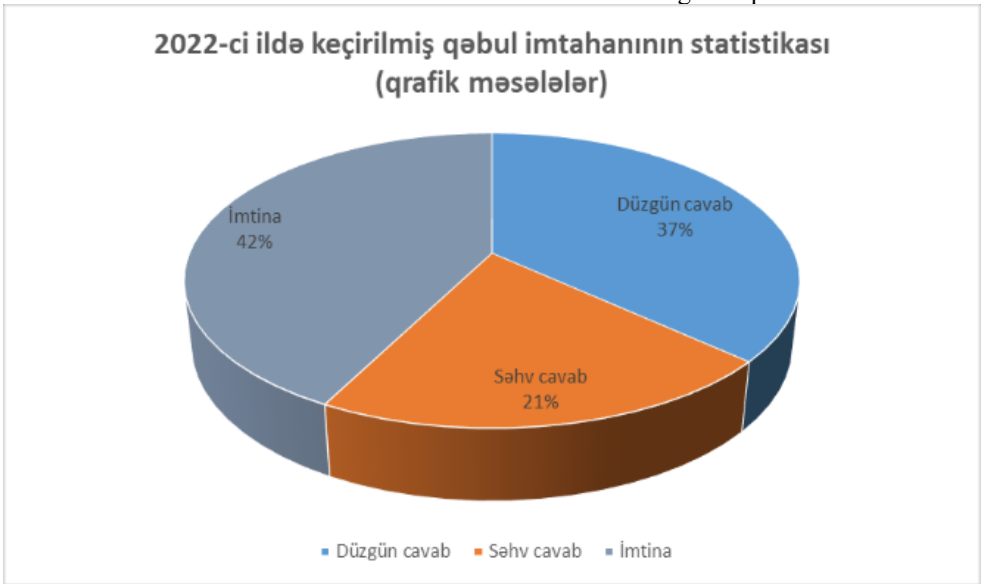
3. Mastering the graphical representation of dependencies between physical quantities

Test blocks contain test tasks of various nominations and difficulty levels. The static analysis of test

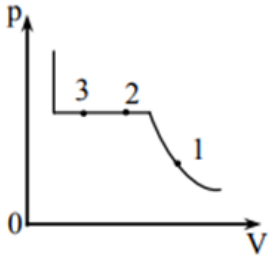
tasks by nominations shows that students either responded poorly or refused to answer graphic issues that determine the functional dependence between physical quantities and focus on revealing the essence of physical phenomena and processes.

From here it can be concluded that these topics are difficult for students to master. Also, there may be certain problems in teaching those tasks.

Our observations show that students have more difficulty answering graphic questions related to the topic of "Saturated and unsaturated steam" from the "Molecular Kinetic Theory" section. Let's look at the statistics of the given question related to that topic.



The process of converting unsaturated steam under the piston in the cylindrical container into liquid by isothermically compressing is described in the diagram (p; V). Which relationship between the masses of steam corresponding to points 1, 2 and 3 is true (p – pressure, V – volume)?



A) $m_1=m_2=m_3$ B) $m_1<m_2=m_3$ C) $m_1>m_2>m_3$
D) $m_1>m_2=m_3$ E) $m_1<m_2<m_3$

The reason for the difficulty in solving the problem is that students cannot determine that the 1 point in a given (p;V) diagram corresponds to unsaturated, and the 2 and 3 points correspond to saturated steam, in short, they cannot read the graph. They cannot here determine how isothermal compression affects the mass of saturated vapor. To complete the task, it is necessary to know that unsaturated steam becomes saturated by isothermal compression, and when compression continues, the mass of steam decreases as a result of the transfer of part of the saturated steam to the liquid. The correct answer is option C.

The conducted analyzes show that students always respond well to tasks related to formulas and units, and relatively poorly to qualitative and graphic tasks.

Statistics show that 36.12% of students answered graphic issues correctly, 22.31% answered incorrectly, and 41.57% refused to answer. 20% of the total test tasks are devoted to graphic issues. Based on the indicators, we can say that the percentage of correct answers is not even half. Also, over the years, the number of graphic issues in the exam questions has decreased. Here, the tasks that students achieve high results are tasks related to calculation and finding a ready-made formula.

After these statistical analyzes, such a question arises. But what is the reason why students easily perform calculation issues and have difficulty in graphic issues?

First of all, we should note that students' familiarity with graphs is more important than physics. They know the functional dependencies between graphs and quantities in mathematics. That is, it is important to create the relationship between physics and mathematics. Such a question arises here. Why can't students apply what they learn in mathematics to other subjects?

Since students memorize functional dependencies in mathematics without understanding their essence, they already face difficulties in solving graphic problems in physics. In other words, the essence of the graph is not clearly explained to them during the teach-

ing of the subject, and the consequences of this are revealed when they encounter it in other subjects. The result of this is clear from the indicators in the statistics mentioned above. Another reason is that the issue books we analyzed do not have much space for such issues. Students are given more quantitative issues as assignments in the teaching process.

In explaining the properties of evaporation and condensation processes of liquids and solids, it is advisable to look at three idealized states:

• Evaporation of fluid at a constant temperature in a vacuum;

• adiobatic evaporation in a vacuum;

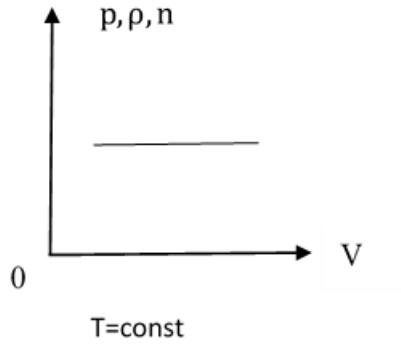
• evaporation and condensation at different temperatures in a closed container.

In the first case, evaporation proceeds with complete evaporation of the liquid at a constant speed. In the second case, evaporation is accompanied by a decrease in temperature, as molecules with maximum kinetic energy leave the surface of the liquid. As a result, the liquid cools down and turns into a solid. With a decrease in temperature, the rate of evaporation decreases.

Evaporation of a liquid or solid in a closed container continues until a dynamic equilibrium is established between evaporation and condensation.

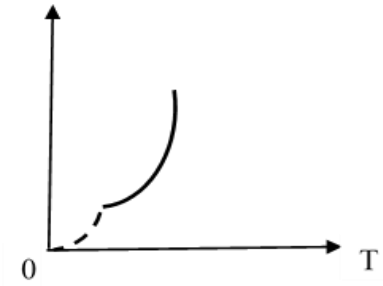
Therefore, due to the nature of density and pressure depending on temperature, students encounter saturated and unsaturated states of steam. Our observations showed that students cannot graphically describe the processes in this direction or determine the states of steam from the finished graph.

Saturated steam is generated above its surface when the liquid is in a closed container. If the mouth of the container is open, the dynamic balance on the liquid surface is disturbed, that is, some of the molecules that leave the liquid surface do not return. At this time, the steam becomes insatiable. Students should know and be able to distinguish the properties of saturated and unsaturated vapors. Then they should be able to graphically describe what they know, or read “on a ready-made graph.



The concentration of saturated vapor molecules at constant temperature does not change (since the rate of evaporation does not change), if the concentration does not change, that is, if the number of molecules in a unit volume does not change, the density and pressure do not change either:

So saturated vapor is not subject to Boyle-Mariott's law as ideal gases. As the temperature increases, the number of saturated vapor molecules increases, which means that its density and pressure also increase:

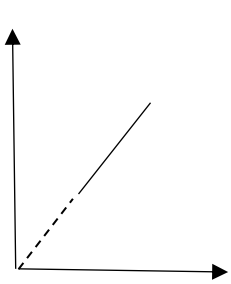


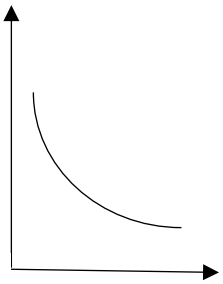
It causes the graph to be parabol so that the concentration of saturated steam increases as the temperature increases:

$$p=nkT$$

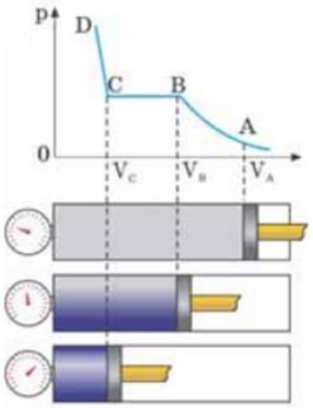
Therefore, the pressure of saturated vapor increases due to both temperature and concentration – saturated vapor does not obey Charles's law.

At constant temperature, the pressure and density of mass insatiable vapor supplied decreases with increasing volume, which is caused by the expansion of mass unsaturated vapor molecules given as the temperature increases. At this point Boyle – Mariott's law is paid for:





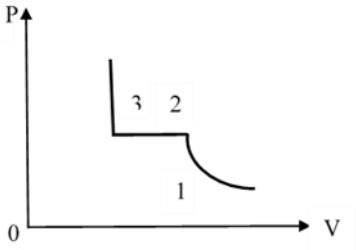
$PV=\frac{m}{M}RT$ - $P\sim\frac{1}{V}$ since m, M, R and T are constant here Pressure of mass insatiable vapor given in constant volume it is directly proportional to the temperature because as the temperature increases speed increases, which means an increase in pressure - Charles's law paid



It is possible to convert one of the saturated and unsaturated vapors into another:

- when the temperature is constant, saturated steam becomes unsaturated steam when it expands;
- when the temperature is constant, unsaturated steam turns into saturated steam when compressed. Issue 1. (p,V) coordinates describe the process of isothermically compressing the unsaturated vapor under the piston in the cylindrical container into a liquid. Determine the relationship between the density of the vapor corresponding to points 1,2, and 3.

It can be seen from the graph that according to the point 1, the vapor is unsaturated, so that as the volume decreases, the pressure increases, the mass of the steam does not change, and its density increases.

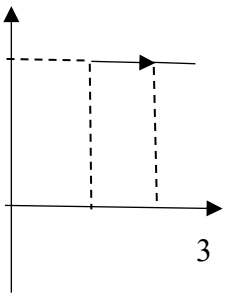


The density of steam corresponding to this point is smaller. According to points 2 and 3, the vapor becomes saturated, so that the pressure does not change even if the volume decreases (the pressure, density, concentration of saturated vapor remains abide in the isothermal process). Therefore, the density of saturated steam corresponding to those points is: ρ_2=ρ_3. In this part, the density does not change as a result of the transfer of some of the vapor molecules to the liquid. So the answer is:

$$\rho_1<\rho_2=\rho_3.$$

If we determine the relationship between the concentration of vapor molecules corresponding to those points, we will see that when we squeeze the vapor at a constant temperature, its pressure increases due to its volume decreases. This part corresponds to the unsaturated state of the vapor. Since the mass does not change, the concentration of vapor molecules increases ($n=\frac{N}{V}$), in this regard, the concentration of steam molecules corresponding to point 1 is the smallest. At points 2 and 3, the vapor is saturated. Since some of the molecules in this part become liquid, the concentration of molecules does not change. Answer: $n_1 < n_2 = n_3$

Issue 2. A graph of dependence on the volume of water vapor pressure at constant temperature is given. How has the mass and density of steam changed in the process?



First, let's analyze the graph. It can be seen from the graph that it is saturated belongs to steam. The mass of saturated steam is directly proportional to the volume to calculate since, let's write the following dependency:

$$\frac{m_2}{m_1} = \frac{V_2}{V_1} = \frac{3V_0}{V_0} = 3.$$

Since the density does not depend on the volume, it will not change.

Thus, if more space is given to the use of graphic issues in the teaching of physics, students can better explain the physical phenomenon by using the graph - being able to read it. In this way, their ability to work with graphs and their thinking will be developed.

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PHILOSOPHICAL SCIENCES

PHENOMENOLOGY AND SEMIOTICS OF THE ARTISTIC IMAGE IN REALIST PAINTING: EXPERIENCE, BELIEF, AND INTERPRETATION

Skovronskyi B.
PhD in Philosophical Sciences, Associate Professor
Department of Design and Fine Arts
Mykhailo Drahomanov Ukrainian State University
Kyiv, Ukraine
ORCID: https://orcid.org/0000-0001-5413-6630
DOI: 10.5281/zenodo.21095379

ABSTRACT

This article examines the artistic image in realist painting at the intersection of phenomenological and semiotic methodologies as a phenomenon formed by human consciousness. Its starting thesis is that the image can be reduced neither to the reproduction of the external features of an object nor to its simple sign substitution; rather, it emerges as a special form of conditional yet convincing reality constituted in consciousness through depiction. In this regard, the central problem of the article is to clarify how a real thing is transformed into an artistic image, which factors ensure this transformation, and what mode such a transformation of content assumes.

The article analyzes the state of scholarly development of the topic in phenomenology, aesthetics, semiotics, and art theory. Special attention is given to the concepts of Husserl, Ingarden, Merleau-Ponty, Losev, and Deely. It is shown that phenomenology makes it possible to describe the image as an intentional object of consciousness, whereas semiotics reveals the mechanisms of its functioning as a sign-mediated form of experience. Particular importance in the study is given to the concepts of belief, experience, presentation, interpretation, and interpretant, through which the mechanism of the emergence of figurative reality is specified.

The article also considers the relationship between phenomenological and semiotic approaches and shows that they do not exclude but rather complement one another in the analysis of the pictorial image. Using examples from well-known works of painting, especially those of Cezanne, it demonstrates that realist painting not only reproduces an object but also forms a special mode of its presence in which the depicted becomes self-sufficient both aesthetically and semantically.

In conclusion, it is argued that the artistic image in realist painting is an intentionally and sign-mediated form of aesthetic reality that arises in the process of correlation between experience and belief, carried out through interpretation and the presentation of the image.

Keywords: artistic image, depiction, realism, painting, phenomenology, semiotics, intentionality, interpretant, presentation, aesthetic perception.

Introduction. The concept of the image belongs to the basic categories of philosophy, aesthetics, psychology, and art studies. In the traditional sense, the image is associated with the reflection of reality in human consciousness, with the formation of an idea of an object, phenomenon, or event, and with the transmission of content through a sensuously expressive form. In this meaning, the image may be interpreted as a "subjective picture of the world," a "sign system," or a "universal carrier of information." At the same time, contemporary culture, marked by multimedia, interartistic synthesis, clip thinking, and complex regimes of visual communication, actualizes the need for a broader, meta-artistic understanding of the image.

Realist painting requires particular attention in this context. Despite the obvious historical stability of this form of art, it is precisely here that the problem of the relationship between depiction and reality, sign and object, the visible and the thinkable, the given and the experienced arises most acutely. Realist depiction reveals a paradoxical nature: it is created from lines, patches of color, and relations of light and shade, that is, from elements that in fact have no commonality with the depicted object, yet at the same time are perceived as its presence. It is precisely this capacity to replace a real thing with its figurative reality that provides grounds for a deeper analysis of the artistic image as a specific mode of being.

In this connection, the artistic image should be considered not merely as the result of resemblance or skillful reproduction of the external appearance of an object, but as a phenomenon of the transformation of content. What is at stake is the transition from a real thing to a conditional but convincing image in terms of belief in the reality of the depicted. Such a formulation of the question requires the simultaneous involvement of two research perspectives - phenomenological and semiotic. The former makes it possible to describe how the image appears in consciousness as an intentional object. The latter makes it possible to trace how depiction functions as a sign that not only denotes but also presents, interprets, and replaces reality.

Problem Statement. The main problem of this article is to clarify the mechanism by which a real thing is transformed into an artistic image in realist painting. This concerns not merely the technical transfer of the external features of an object onto the surface of a painting, but a more complex process as a result of which a real object acquires the form of a conditional yet convincing presence in the consciousness of the recipient. In this sense, the question arises: what exactly makes a depiction an image? Why is a system of lines

and patches of color perceived not as a set of material elements but as a certain autonomous reality?

Within the framework of this problem, several more specific tasks must be solved. First, it is necessary to distinguish between the concepts of "image" and "depiction," since their identification obscures the specificity of artistic perception. Second, the factors that ensure the semantic transformation of an object into an image must be identified. Third, it is important to determine the role of experience, belief, intention, presentation, and interpretation in the process of image formation. Fourth, it is necessary to establish the relationship between phenomenology and semiotics in explaining the artistic image. Finally, it is necessary to critically evaluate the conception according to which the image in realist painting is an autonomous reality of consciousness arising as a result of the correlation between experience and belief.

Analysis of the State of Scholarly Development of the Topic. The problematics of image, depiction, and artistic reality are interdisciplinary in nature and have been developed in various intellectual traditions. In phenomenology, the foundational works for this topic are those of Husserl, who analyzed the intentionality of consciousness, the mechanisms of the constitution of the object, and the difference between sensory givenness and the object of intention (Husserl, 2014). His ideas were important for the further understanding of artistic perception as a special mode of givenness.

Within phenomenological aesthetics, the problem of depiction and the work of art was developed by Ingarden, who investigated the multilayered structure of the work of art, in particular the relationship between the material layer of depiction and the layer of reconstructed "aspects" (Ingarden, 1989). This made it possible to describe the internal structure of the pictorial work, although the question of the image in a broader sense remained open.

A special contribution to the understanding of visual experience and the specificity of painting was made by Merleau-Ponty, who connected perception not with the passive registration of the world but with the bodily rooted experience of vision (Merleau-Ponty, 2012). His proposition that depiction imitates not merely the object but the way it appears in experience is fundamental for this topic.

In terms of the aesthetic analysis of the work of art, an important place belongs to the works of Losev, who investigated myth, artistic form, and the specificity of the semantic being of the image (Losev, 1994, 1995). His reflections provide grounds for interpreting the image as a special reality of belief. Also significant for the analysis of depiction as a cultural form is the contribution of Lehenkyi, who considered depiction in the context of compositional synthesis and the cultural study of the image (Lehenkyi, 1995).

In semiotics, the concept of Deely is of key importance for this topic. Building on the line of Peirce, Deely analyzed the nature of the sign, object, interpretation, and interpretant (Deely, 2005). His approach makes it possible to see that depiction functions not merely as a bearer of visual information, but as an element of a more complex semiotic process in which meaning arises as a result of the triadic structure of signification.

Thus, the scholarly development of the topic demonstrates the presence of two powerful lines of analysis - phenomenological and semiotic. At the same time, what still requires further elaboration is precisely their combination in the study of realist painting, as well as clarification of how intentional givenness, sign structure, experience, belief, and aesthetic autonomy are combined in the pictorial image.

Research Methodology. The methodological basis of the article is the combination of phenomenological, hermeneutic, and semiotic approaches. The phenomenological method is applied to describe the image from the point of view of its immediate givenness to consciousness, the mode of its intentional constitution, and its lived experience. The hermeneutic approach makes it possible to trace how the meaning of the work is formed in interaction with interpretation. Semiotic analysis is used to clarify how depiction functions as a sign, what its structure is, and what role the interpretant plays in the formation of the image.

The study is theoretical and analytical in nature and is based on a comparative consideration of the concepts of Husserl, Ingarden, Merleau-Ponty, Losev, and Deely. In addition, the method of art-historical interpretation is used for the analysis of specific examples from painting.

Phenomenology and semiotics are often presented as alternative approaches: the former focuses on consciousness and lived experience, the latter on signs and structures of signification. However, in the case of realist painting, it is advisable to regard them not as mutually exclusive but as complementary methodologies.

Phenomenology makes it possible to clarify **how** the image is given to consciousness. It describes it as an intentional object constituted on the basis of sensory material, experience, attention, reduction, and vision. It explains the internal mechanism of the transition from the material plane to figurative presence.

Semiotics, in turn, makes it possible to clarify **through what** and **within what structure** this transition takes place. It shows that depiction functions as a sign-bearer, that its meaning is not immediate but arises in the process of interpretation, and that the interpretant plays a key role in this.

Thus, phenomenology describes the image from the side of its lived experience, whereas semiotics describes it from the side of its sign organization. Their combination makes it possible to see that the artistic image is both an intentional and a sign-based formation. It does not exist without consciousness, but neither is it reducible to subjective experience; it has a material basis, but is not exhausted by it; it functions as a sign, but is not equal to mere signification.

It is precisely in the process of such a synthesis that the most relevant theoretical model of the artistic image in realist painting appears possible.

The phenomenological approach of Husserl allows one to consider the image not as a thing that simply exists in the external world, but as the result of the intentional activity of consciousness (Husserl, 2014). For Husserl, sensory data never coincide with

the object itself. What we see is given to us in "adumbrations" - partial, changing, perspectivally conditioned moments of perception. The object as a stable whole emerges only thanks to the synthesis performed by consciousness.

Applied to painting, this means that patches of color, contours, and textural relations are not the image itself. They perform a representational function and serve as sensory material on the basis of which consciousness constitutes an intentional object. The image does not simply "reside" in the depiction; it is formed as a result of consciousness being directed toward this sensory material. Thus, already at the level of Husserlian analysis, the fundamental difference between the material plane of the painting and the image as that which arises in experience becomes evident.

Phenomenological reduction acquires special significance here. When contemplating a painting, the recipient, on the one hand, does not cease to know that what stands before them is a surface covered with paint. On the other hand, this material factuality is reduced, pushed into the background. Consciousness, as it were, "brackets" the immediate material status of the depiction in order to open another level of givenness - the figurative one. Reduction becomes the means that allows the plane to be transformed into the space of the image.

However, in Husserl the question remains insufficiently clarified as to why consciousness agrees to see in a material depiction the image of a real thing. His conception convincingly describes the mechanism of intentionality, but explains less distinctly the motivational moment of the transition from perceiving the means of depiction to accepting figurative reality. It is precisely this lacuna that makes an appeal to other concepts necessary.

Ingarden develops phenomenological analysis toward a special investigation of the work of art (Ingarden, 1989). In his view, the painting has a multilayered structure. Its first layer is formed by the material means of depiction - paints, lines, textures, and visually fixed elements. The second layer consists of the "aspects" of things reconstructed in these elements.

This distinction is methodologically important because it makes it possible to see clearly that in painting two realities always coexist: the material and the intentional. Ingarden shows that the aspect is not identical with the physical depiction, but arises as a result of its perception. In this sense, the "aspect" may be interpreted as the phenomenological correlate of reproduced visual experience.

At the same time, the concept of "aspect" does not fully encompass what is meant by image. An aspect is first of all a mode of the visual appearance of a thing, its perceived side. The image includes more: not only appearance, but also semantic intention, emotional orientation, and aesthetic organization. That is why, although Ingarden's approach is extremely useful for the analysis of the structure of the painting, it cannot exhaustively explain the artistic self-sufficiency of the image.

From this perspective, the image is broader than the reconstructed "aspect." It not only reproduces the experience of seeing, but also endows it with a new status - the status of aesthetically significant reality.

In the conception of Merleau-Ponty, the problem of the pictorial image is transferred to the plane of bodily rooted perception (Merleau-Ponty, 2012). Unlike a purely representational understanding of depiction, Merleau-Ponty shows that perception is an active, bodily, and ontologically rooted process. A thing is not simply given to us; it opens itself within a field of vision structured by the body, movement, habit, and the horizon of experience.

In this context, the idea that depiction imitates not so much the object itself as **visual experience** is especially important. That is why several conventional strokes can evoke the impression of a face, and relations of shadow and light the impression of volume. The realism of a painting lies not in the literal duplication of a thing, but in the reproduction of the conditions of its recognition.

Merleau-Ponty also helps one look differently at the problem of belief. If the image becomes convincing for consciousness, this happens because consciousness recognizes in it the structure of already assimilated experience. But this recognition is not automatic: it requires a certain act of belief in the depiction. Experience forms the horizon of the possible, and belief performs the act of acceptance. It is precisely at this point that Merleau-Ponty's phenomenology begins to intersect with the line developed in the author's text.

Also important is Merleau-Ponty's assertion that in "normal perception" the content of what is perceived appears as instituted in the thing itself, rather than as arbitrarily constructed by the subject (Merleau-Ponty, 2012, p. 339). This means that in the experience of a painting, consciousness does not simply impose meaning on the material surface, but responds to a certain semantic proposal embedded in the mode of depiction. Thus, the image arises as a meeting of experience and intention.

Losev's philosophy of the image makes it possible to move from the analysis of perception to the analysis of the semantic self-sufficiency of the image (Losev, 1994, 1995). For Losev, myth is not simply fiction, but a real form of consciousness for the one who lives within it. This thesis has a direct bearing on art, since the artistic image likewise functions as a reality of belief.

When Losev speaks of the image, he in effect shows that meaning is not exhausted by external visibility. External appearance can substitute for another, deeper reality, and act on its behalf. This is especially important for painting: depiction not only presents an object, but becomes its image, that is, its semantic representative endowed with its own power of presence.

No less significant is Losev's conception of artistic form (Losev, 1995). In the philosopher's reflections, artistic form is dual: it always contains both **what** is manifested and **how** it is manifested. It is precisely this "duality" that creates artistry as a special form of adequacy between content and the mode of its expression. Thus, the artistic image is not merely a sign of an object; it is the realization of a certain idea of vision, a certain idea of expression.

From this follows an important conclusion: the artistic self-sufficiency of the image lies not in a break with the object, but in the fact that the object is given in it already in a transformed, semantically intensified form. That is why aesthetic interest is concentrated not on the thing itself, but on the image of the thing, on the way in which it appears before consciousness.

Deely's conception is key to the semiotic understanding of depiction (Deely, 2005). Unlike binary models of the sign, Deely emphasizes that semiosis always has a triadic structure: sign, object signified, and interpretant. Thanks to this, the sign does not merely point to an object, but enters into complex relations with consciousness, experience, and meaning.

For the analysis of painting, the concept of the **sign-vehicle** is particularly important. Depiction functions as a vehicle of experience: it objectifies visual experience and makes it available to consciousness. But in itself it is not yet an artistic image. It merely creates a pattern, a schema, that requires interpretation.

In this context, the interpretant is what transforms the sign structure into a meaningful situation. It is not simply a commentary or external explanation, but a conditional though factual-for-consciousness picture of what follows from the relation between sign and signified. In the case of painting, the interpretant may be understood as the situation of seeing in which the depicted is perceived as present.

Especially valuable in Deely is the understanding that the sign does not merely replace the object, but appears as an independent object that "stands for something other than itself" (Deely, 2005). This means that in painting what matters is not only what is depicted, but also how exactly the sign realizes its substitution. Here semiotics comes directly close to the problem of artistic form.

The interpretant also turns out to be the meeting place of experience and belief. Presentation appeals to experience because it is oriented toward recognition. But at the same time it requires belief, since the depicted object is not directly present. In this sense, the interpretant is the factual situation in which consciousness accepts the conditional reality of the image.

Presentation of the Main Material. If we take the methodological principles described above as our basis, it can be said that belief, on the one hand, and experience, on the other, are two intentions, one of which is directed by consciousness toward reality, while the other is, conversely, a projection of reality onto consciousness. In this sense, the image does not imitate real actuality, but becomes "personal being" (Losev, 1994, p. 73); on the basis of the givenness represented by depiction, it creates its own self-sufficient consciousness. "Its own" in the sense that this consciousness expresses and concerns only that which is given in the concrete image. In this sense, a still life with fruit on a tablecloth, Mont Sainte-Victoire, a face from a Fayum portrait, warriors on a Greek relief or on a Scythian pectoral - all these are realities which, from the moment of their creation, live their own self-sufficient life nourished only by experience and belief. Thus, the reality of images becomes self-sufficient; it replaces the perception of the real thing. In this connection, one may say that the image becomes those "eyes" through which we look at reality, that is, an analogue of perception in Merleau-Ponty's sense or an "iconic equivalent of perception" in Eco's sense. In this regard, the phenomenon of seeing acquires the significance of a key factor; it consists in the concretization of the motive, that is, the desire to see in what is depicted the image of this or that object. This means the comprehension of a particular configuration of spots and lines on a plane as the depicted object given through the mediation of these spots and lines. What is lacking in the scheme described is only one link - the mediator, the means by which the very process of correlation, that is, the "meeting" of experience and belief, takes place.

Experience requires objectification, that is, awareness, and therefore there arises a need for a carrier through which experience is transmitted and fixed, since only in this case can it be applied by consciousness. According to Deely (2005), a thing not reduced to experience exists separately from human thought - physically or really. By contrast, a thing already tested in experience and thereby made conscious becomes an object. Thus, an object is a thing that exists in experience, or more precisely, "acquires existence according to experience." The fixing means here is the sign as a "pattern" "according to which things and objects interweave to form the fabric of experience" (Deely, 2005, p. 109). Therefore, it is precisely the sign that objectifies experience, expressing it and making it "available through some sensory modality" for understanding (Deely, 2005, p. 110). In our case, such a "sensory modality" is depiction, which objectifies visual experience by representing it through the "aspect" of the depicted thing.

If the artist has at their disposal the means of depiction on the one hand and the object of depiction on the other, then at the basis of depiction there will always be an idea - an understanding of **how** to apply, group, distribute, combine, juxtapose, and so on, these means in such a way as to convey through them the idea of the depicted object as adequately as necessary for it to persuade and induce belief in the depicted object. But at the same time, it is also the idea of expression itself, which induces belief not in the actual object, whose existence, as shown above, is "put in quotation marks," reduced, but in the depicted object, and in the object depicted **precisely in this way**. Perhaps the best illustration of this is Cezanne's series of views of Mont Sainte-Victoire. In this case, we have the same prototype - the mountain landscape and the field before it, depicted from an analogous or even identical angle. Only the images in which this landscape appears differ. What does the evolution of these images consist in, if not in the evolution of the very idea of expression? If this is so, then the question arises: what does such an idea persuade us of? And what is its aim? In any case, the verisimilitude of depiction is not the aim here. The idea represents not the mountain and its surroundings, but the very mode of depiction or **seeing**; it emphasizes not the actual reality of the landscape, but seeks to persuade us of the reality of the landscape depicted **in just this way**. That there exists a real object - Mont Sainte-Victoire - is also clear from the depiction, but this reality, or rather its idea, is not dominant. What interests

the artist is not the appearance of the mountain in actuality, but its image, **vision realized in a certain idea** of the construction of the depiction. It is precisely as a consequence of such a duality of ideas and their correlation that the self-sufficiency of the artistic image arises. This self-sufficiency consists in the fact that the object of belief becomes not so much the depicted object itself, not so much its own verisimilitude, as its understanding - the image - and therefore the idea of its expression, the compositional idea through which this image is formed. The value emphasis of form, taken specifically as "artistic," is thus shifted from objective givenness to its interpretation.

It must be especially emphasized that the sign does not simply replace the object signified, but is taken as an independent object, fundamentally different from that which it signifies. The sign is an object. It does not simply "stand for another," but "stands for something other than itself," as Deely (2005) emphasizes. In that case, the interpretant becomes that "marker" from which it becomes clear **how** the sign enters into relations with "something other" - with the signified. Thus, what is at issue is that the interpretant reflects the mode of signification, and more specifically, the mode of expression, since the sign, in the case of depiction, not only replaces but expresses the signified.

In light of the above, the relation between the idea and the interpretant also becomes clear. The objecthood of the sign, its difference from the signified, determines the mode of expression carried out by the sign as the representation or presentation of the signified before human consciousness. Consciousness has no access to the signified object itself; it has access only to the sign that presents this object, standing in for it and replacing it. One may say that the sign reveals the substituted object by presenting it, in the case of depiction by showing its appearance. Presentation is nothing other than the transmission of content into consciousness, its representation in a certain appearance or form. It is evident that this appearance or form is presentation itself, since it is only in it that content resides and is expressed; therefore, the understanding of content is determined solely by its presentation, or more precisely, by the mode of its realization.

Thus, depiction as an "aspect" in Ingarden's terminology, presented by the sign, becomes for consciousness that object in reaction to which, according to Santayana (2014), "belief is imperceptibly imposed upon the organism." The presentation of the "aspect," or more precisely the idea of this presentation, is what induces belief in the object signified by the sign but not directly present. Consciousness is simply left with no alternative but to accept on faith what is presented, relying on previously acquired experience and guided by the idea of presentation itself.

The above reflections may be reduced to the following. Presentation as a mode of expressing content is the idea in which lies the inducement to believe in the object signified by the sign. The interpretant, accordingly, is that from which consciousness learns, and on the basis of which it judges, the signified object - the appearance in which the latter appears before consciousness.

From what has been said, an important conclusion may be drawn regarding the interpretant: its indifference with respect to actuality. The interpretant is a factual situation that is not determined by actuality, although it may correspond to it or not, but is accepted on faith. Recalling Losev's reflections, one may say that the interpretant is a myth through which consciousness makes sense of a particular phenomenon of actuality and which accordingly replaces that actuality, that is, itself becomes for consciousness the reality with which it connects and within which it thinks its own existence (Losev, 1994).

Thus, the two pairs of binary relations discussed above - "sign-signified" and "sign-human being" - are transformed, with the introduction of the interpretant, into a ternary relation: sign-interpretant-signified. As can be seen, the sign performs in these relations the function of mediator between two spheres - human consciousness and actuality. The interpretant, in turn, performs the function of a referent that speaks both on behalf of consciousness and on behalf of actuality, namely: it allows consciousness to make sense of actuality through a factual situation into which it is introduced, and it allows actuality to be reflected in consciousness through presentation, in the realization of which the factual situation consists. This is the basis for the following conclusion. The situation created by the interpretant is realized in the first case as belief, because the interpretant is a situation accepted on faith, and in the second as experience, since presentation appeals to experience and is designed for the recognition in the "aspect" presented by the sign of the signified object. Therefore, it may be said that the interpretant becomes the situation in which belief and experience are correlated. In accordance with the above, the mode by which these two factors correlate is presentation.

Conclusions

Summarizing the course of the above reflections, it may be said that the mode of correlating experience and belief is the creation of a factual situation in which consciousness, through presentation, realizes vision as an idea, and therefore as belief, since belief is an idea in intention, while by means of the sign the experience of seeing, that is, visual experience, is realized. The factual situation in question is the situation of interpretation, which realizes itself as presentation. This coincides with the resolution of the antinomy of the two types of sign relation: sign-signified and sign-consciousness, the medium of whose synthesis becomes the interpretant. The latter thereby combines two qualities: it appears as consciousness, in which the signified is reflected, and at the same time as actuality, that is, a conditional yet real-for-consciousness "picture" in which this actuality appears before it. One may say that consciousness thus **transforms actuality**, that is, modifies it, adapting it to its own needs. Yet actuality also moves toward consciousness, convincing it of the reality of what has been seen, appealing to previously acquired experience and calling upon it to rely on that experience. Of course, this may be assumed only if one remembers that what is at issue is a conditional situation in which actuality is represented, and therefore replaced, by the sign - the depiction - which is taken for

actuality, while the reality of what is depicted is subject to phenomenological reduction.

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TECHNICAL SCIENCES

THE EFFECT OF ENVIRONMENTAL PARAMETERS ON THE REACTANCE PARAMETER OF THE OVERHEAD POWER TRANSMISSION LINE WITH THE UNBUNDLED PHASE

Chyzhevskyi V.
Candidate of Technical Sciences,
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute",
Kyiv, Ukraine
DOI: 10.5281/zenodo.21095403

ABSTRACT

Changes in environmental parameters (temperature, atmospheric pressure, air humidity, wind speed, solar radiation etc.) cause changes in the electrical parameters of electrical power equipment. However, in most cases, this effect is accounted for solely by taking into account the temperature dependence of the active resistance, which varies in proportion to the temperature coefficient of resistance of the conductor material and a temperature by itself.

At the same time, changes in environmental parameters also affect other electrical parameters of electrical power equipment – reactance, conductance and susceptance. The corresponding dependencies are less obvious and, in terms of their relative impact on parameter values, less significant than the dependence of resistance on temperature. However, in case of the wide range of variation in environmental parameters, such an effect may be significant for technical or economic calculations.

This paper examines the influence of environmental parameters of temperature, atmospheric pressure and air humidity on the reactive resistance of an overhead power transmission line with an unbundled phase.

Keywords: power transmission line, reactance, temperature, atmospheric pressure, air humidity.

Introduction

The modern power industry is a complex technical system, the reliability and efficiency of which depend to a large extent on the proper consideration of the operating conditions of the equipment. One of the key factors influencing the operation of power facilities is environmental conditions. Air temperature, humidity, atmospheric pressure, wind speed, solar radiation, ice, atmospheric pollution and other natural factors can significantly alter the electrical characteristics of equipment, affecting its service life, reliability and operational safety. This is precisely why taking the impact of the environment into account is an integral part of the design, operation and modernisation of power systems.

Of all the environmental parameters, temperature is the most significant factor affecting the electrical characteristics of electrical power equipment. It is well known that the electrical resistance of conductive materials increases with rising temperature in proportion to the temperature coefficient of resistance [1]:

$$R_{T2} = R_{T1} \cdot \left(1 + \alpha \cdot (T_2 - T_1)\right), \quad (1)$$

where:

R_{T1} – the DC resistance at temperature T_1;

R_{T2} – the DC resistance at temperature T_2;

α – the temperature coefficient of electrical resistance at temperature T_1.

Consequently (1), as the ambient temperature rises, active power losses increase in power transmission lines, substation busbars, cables and the windings of electrical machines.

The temperature changes also affect the mechanical properties of conductors. For example, the heating of overhead power line conductors causes them to elongate and increases sag, which can lead to a breach of standard dimensions and the occurrence of emergency situations [2]. In transformers, temperature determines the permissible load, dictates the rate of insulation ageing and the overall service life of the equipment [3].

The level of humidity determines the rate at which conductive films form on the surfaces of insulators and electrical equipment, thereby increasing leakage currents and the likelihood of surface breakdown of the insulation. A combination of high humidity with surface contamination from dust or industrial emissions is particularly dangerous, as under such conditions the electrical strength of the insulation is significantly reduced and the risk of emergency outages increases.

Wind speed also has a significant impact on the operation of electrical power equipment. On the one hand, wind improves the cooling of conductors, transformers and other network components, thereby increasing their capacity. On the other hand, strong winds place additional mechanical stress on pylons, cables and insulators. Under certain conditions, dangerous vibrations and oscillations of the cables may occur, which accelerate their wear and tear and increase the probability of damage.

Solar radiation is another significant factor influencing the electrical parameters of power equipment. Under the influence of solar radiation, the surface temperature of cables and equipment can significantly exceed the ambient air temperature. This affects the thermal operating conditions of electrical installations, alters the electrical resistance of conductors and limits permissible current loads. This is precisely why the intensity of solar radiation must be taken into account when calculating the capacity of overhead power lines.

Thus, environmental parameters have a direct impact on the electrical, thermal and mechanical characteristics of electrical power equipment. Ignoring this impact can lead to design errors, equipment overload, accelerated ageing of insulation and the occurrence of

emergencies. Therefore, taking environmental parameters into account is a necessary prerequisite for ensuring the efficient, safe and reliable operation of modern power systems.

For a number of electrical parameters of power equipment, the effect of changes in environmental conditions is negligible almost negligible. However, in case of the wide range of variation in environmental parameters, such an effect may be significant for technical or economic calculations. One such parameter is the reactance of power transmission lines, the values of which can also be expressed as a function of environmental parameters.

Calculation of the reactance of an overhead power line transmission with an unsplit phase with an unbundled phase

It is known that the reactance per length of an overhead power line with an unbundled phase can be determined as follows [4]:

$$x_0 = \mu_0 \cdot f \cdot \left(\ln\left(\frac{2 \cdot D_{GM}}{d_w}\right) + \frac{\mu_r}{4}\right), \quad (2)$$

where:

μ_0 – vacuum permeability ($\mu_0 \approx 4\pi \cdot 10^{-7}$ H/m);

f – voltage frequency;

μ_r – relative permeability of the power transmission wires material;

d_w – outer diameter of the power transmission wires;

D_{GM} – geometric mean distance between the phases of the power transmission line, which can be calculated as:

$$D_{GM} = \sqrt[3]{D_{1-2} \cdot D_{2-3} \cdot D_{3-1}}, \quad (3)$$

where:

$D_{1\text{-}2}$, $D_{2\text{-}3}$, $D_{3\text{-}1}$ – distances between the axis of the power transmission line phases as given on Fig. 1.

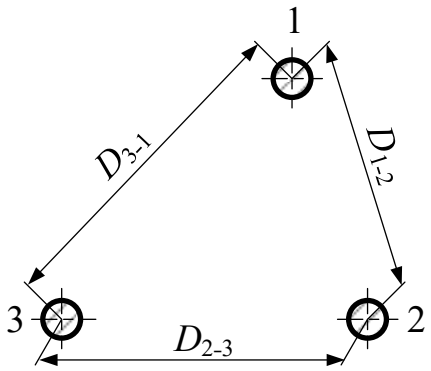

Figure 1. The spatial arrangement of the phases of an overhead power transmission line with the unbundled phase

The effect of temperature on the reactance of an overhead power line with an unbundled phase

The magnetic constant, the voltage frequency and the root-mean-square distance between the phases of the overhead power line, which are included in (2), are independent of the ambient temperature.

The dependence of a conductor material's relative magnetic permeability on temperature is determined by the type of material.

For copper, which is diamagnetic, the relative magnetic permeability is practically independent of temperature and, within the temperature range of –50°C…+70°C (where +70°C is the highest permissible temperature of the copper wire in the continuous steady state condition), can be regarded as a constant to an accuracy less than 10^{-7} (μ_{Cu}=0,999992).

For aluminium, which is paramagnetic, the temperature dependence of the relative magnetic permeability is described by Curie's law:

$$\mu_r(T) = 1 + \frac{C}{T}, \quad (4)$$

where:

C – Curie's constant, which is independent of the ambient temperature;

T– absolute temperature.

If considering $\mu_{r\,Al}$(+20°C)=1,0000220 and taking (4) into account then for the temperature range of –50°C…+70°C (where –50°C approximately equal to the lowest temperature in Europe and +70°C is the highest permissible temperature of the aluminium and steel-aluminium wires in the continuous steady state condition) can be obtained $\mu_{r\,Al}$(–50°C)=1,0000289 and $\mu_{r\,Al}$(+70°C)=1,0000188.

The absolute change of the aluminium relative permeability in the temperature range of –50°C…+70°C is 10^{-5} or 0,001%.

For the steel-aluminium wires the dependence of a conductor material's relative magnetic permeability on temperature is more complicated because of steel core influence. In this case total magnetic permeability of the steel-aluminium wire $\mu_{r\,w}$ can be calculated as follows:

$$\mu_{r\,w} = \mu_{r\,Al} \cdot \left(\frac{I_{Al}}{I}\right)^2 + \mu_{r\,St} \cdot \left(\frac{I_{St}}{I}\right)^2, \quad (5)$$

where:

$\mu_{r\,St}$ – relative permeability of steel;

I_{Al} – current flowing through the aluminium part of the wire;

I_{St} – current flowing through the steel part of the wire;

I – total current flowing through the wire.

For steel, the relative magnetic permeability is a function of the magnetic flux density, the magnetic field strength and the temperature; therefore, its value is usually determined as follows:

$$\mu_{r\,St}(T) = \frac{B(T)}{\mu_0 \cdot H(T)}, \quad (6)$$

where:

$B(T)$ – functional dependence of magnetic induction on temperature;

H (T) – functional dependence of the magnetic field strength on temperature.

As a rule, the value of the ratio $B(T)/H(T)$ is determined from the $B(H)$ graphs plotted for a certain temperature:

$$\mu_{r\,St}(T) = \frac{B(T)}{\mu_0 \cdot H(T)}, \quad (6)$$

For the simplified calculations the relationship between the relative magnetic permeability of steel and temperature can be expressed as:

$$\mu_{r\,St}(T) = \mu_{r\,\mathrm{St}\,+20°C} \cdot (1 - 0{,}002 \cdot \Delta T), \quad (7)$$

where:

$\mu_{r\,St\,+20°C}$ – steel relative magnetic permeability at a temperature of +20°C;

ΔT – the temperature difference between the strand temperature T and 20°C:

$$\Delta T = T - 20°\mathrm{C}. \quad (8)$$

Changes in ambient temperature and the current load on the wire cause the wire's diameter to change. For each strand in the wire assembly, the change in strand diameter as a function of temperature $d(T)$ can be determined as:

$$d(T) = d_{+20°C} \cdot (1 + \alpha \cdot \Delta T), \quad (9)$$

where:

$d_{+20°C}$ – strand diameter at a temperature of +20°C;

α – the coefficient of linear thermal expansion of the strand material (for aluminium $\alpha=23\cdot10^{-6}$ °C^{-1} [5], for copper $\alpha=17\cdot10^{-6}$ °C^{-1}, for steel $\alpha=12\cdot10^{-6}$ °C^{-1}).

The number and diameter of the strands in the construction of copper, aluminium and steel-aluminium cables can be determined in accordance with standard [5].

The effect of atmospheric pressure and air humidity on the reactance of an overhead power line with an unbundled phase

Atmospheric pressure and humidity levels have no direct effect on the components of (2).

At the same time, changes in air humidity lead to changes in the heat dissipation process from the conductor, whilst changes in atmospheric pressure lead to changes in the convection process, which affect the conductor's temperature; this, in turn, affects the value of μ_r.

A change in the temperature of the conductor causes a change in the mechanical tension within it, which leads to a slight change in the value due to a change in the domain structure of the steel core of the steel-aluminium conductor. At the same time, these effects are extremely weak, which means they can be disregarded over a wide range of variations in relative humidity and atmospheric pressure.

Results of calculations of changes in the reactance of an overhead power line due to changes of the environmental parameters

A calculation was carried out to determine the change in the reactance per 1 km of an overhead power line in the event of changes in environmental parameters for an overhead line constructed using PM110-1F type pylons (Fig. 2), for copper, aluminium and steel-aluminium wires at temperatures of –50°C, +20°C and +70°C. The results of the calculations are given in Table 1.

Table 1.

Results of calculations of the reactance per 1 km of an overhead power line based on different types of supports and conductors at various temperatures

Wire type [5]	Material	Reactance per 1 km X, Ohm, for temperature, °C		
		–50	+20	+70
A 120	aluminum	0,4389	0,4389	0,4388
M 120	copper	0,4390	0,4389	0,4389
AC 120/19	aluminum-steel	0.4426	0,4403	0,4394

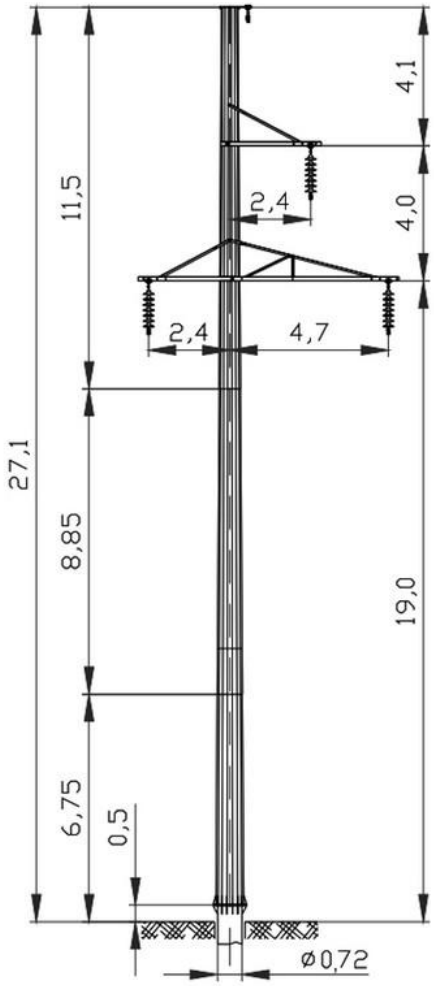

Figure 2. PM110-1F-type pylon diagram

Conclusions

It has been established that environmental parameters influence the reactance of an overhead power transmission line. The greatest influence comes from changes in ambient temperature, which affect both the relative magnetic permeability of the conductor material and the conductor's diameter. However, for overhead power transmission lines with aluminium and copper wires within the temperature range of –50°C…+70°C, this effect is negligibly small, whilst temperature changes have the greatest impact on the reactance of overhead power transmission lines with aluminium-steel wires.

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IDENTIFICATION OF LOW-FREQUENCY OSCILLATIONS OF PARAMETERS IN POWER SYSTEMS USING NON-PARAMETRIC METHODS OF REAL-TIME SIGNAL ANALYSIS

Chyzhevskyi V.
Candidate of Technical Sciences,
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute",
Kyiv, Ukraine
DOI: 10.5281/zenodo.21095417

ABSTRACT

Over recent decades, low-frequency oscillations in operating parameters have caused a number of major incidents in power systems and unions. The consolidation and expansion of these systems and unions increases the risk of low-frequency oscillations arising within them, due to the emergence of new interconnections, power equipment with inappropriate settings, and so on.

To enable the timely detection of risks to the oscillatory instability of power systems and unions, problem-oriented monitoring systems require access to relevant real-time information on the frequencies and damping coefficients of the dominant modes of low-frequency oscillations.

This article presents the results of research into the feasibility of applying non-parametric signal analysis methods to determine the parameters of low-frequency oscillations in electrical parameters in real time.

Keywords: low-frequency oscillations, real-time signal analysis, non-parametric methods.

Introduction

The occurrence of low-frequency oscillations in power systems and unions poses a risk of interconnections being disconnected and of the power equipment in these systems and unions ceasing to operate in parallel. To prevent such situations, the processes leading to the occurrence and development of low-frequency oscillations in power systems and interconnections must be constantly monitored.

The algorithms used by low-frequency oscillation monitoring systems are often based on determining the eigenvalues of power systems and unions, which are calculated from the results of studies of their computer models. At the same time, it is often impossible to obtain up-to-date and complete information on the status of the electrical connection diagrams of equipment, its configuration parameters, operational status and the settings of automatic process control systems in power systems and unions. This may be due to equipment damage or failure, disruptions to communication channels caused by natural or human factors, and so on. In such a situation, the calculation of eigenvalues to identify the risk of low-frequency oscillations in power systems and unions may yield distorted results, which, in turn, will lead to an inadequate assessment of the risk of oscillatory instability in their parallel operation.

Another approach to providing the information component of monitoring systems for low-frequency oscillations is to use signals indicating changes over time in the operating parameters of power system objects and interconnections – such as voltage, current, active power, and so on. With this approach, in order to promptly detect the threat of a loss of oscillatory stability in the parallel operation of power systems and interconnections, it is necessary to ensure rapid analysis of these signals, determining the amplitudes and damping factors of the dominant modes of these oscillations in real time. Various signal analysis methods can be used to carry out such an analysis – Fourier transform, non-parametric and parametric methods, wavelet transform, Stockwell transform, Hilbert–Huang transform, etc [1].

The aim of this article is to investigate the possibility of using non-parametric analysis methods to determine the parameters of low-frequency oscillations in real time.

Non-parametric methods of signal analysis

Non-parametric methods of signal analysis make no assumptions regarding the model of the signal under analysis when calculating its spectrum; therefore, its parameters are determined solely on the basis of the information contained in the signal readings. Non-parametric methods of analysis include the periodogram, the spectrogram, and the Welch and Thomson methods [2].

A periodogram is an estimate of the spectral power density (SPD) obtained from N samples of a single realisation of a random process by averaging a finite number of terms. The periodogram is calculated as follows [2]:

$$W(\omega) = \frac{1}{N \cdot f_d} \cdot \left| \sum_{k=0}^{N-1} x(k) \cdot e^{-j \cdot \omega \cdot k \cdot T} \right|, \quad (1)$$

where:

$x(k)$ – discrete signal;

ω – angular frequency;

f_d – signal sampling rate;

N – number of signal readings;

k – harmonic component number;

T – signal period.

Expression (1) bears a certain similarity to the expression defining the discrete Fourier transform [2], but, due to the squaring of the expansion coefficients, the dominant frequencies will be highlighted more clearly when constructing a periodogram than when using the discrete Fourier transform.

In order to calculate the SPD using a modified periodogram, weighting functions (windows) with coefficients $w(k)$ are applied:

$$W_m(\omega) = \frac{1}{f_d} \cdot \frac{\left| \sum_{k=0}^{N-1} x(k) \cdot w(k) \cdot e^{-j \cdot \omega \cdot k \cdot T} \right|^2}{\sum_{k=0}^{N-1} |w(k)|^2}. \quad (2)$$

The use of weighting functions allows to reduce the high-frequency components of the spectrum, which may be caused by noise (interference) present in the signal.

An important feature of the periodogram is that it cannot be used to obtain an adequate estimate of the signal's mean square error, as the variance of such an estimate may be close to the square of its mathematical expectation, regardless of the number of samples N in the signal data set. This characteristic of the periodogram significantly reduces its suitability for determining the parameters of low-frequency oscillation components in real time.

A spectrogram is an instantaneous, time-dependent spectrum of a signal. To calculate a spectrogram, the signal is divided into segments, for each of which a fast Fourier transform is computed. To illustrate how the amplitude of the signal spectrum changes over time, a graphical representation of the spectrogram is usually plotted in time–frequency (t–f) coordinates, although graphs of the amplitude spectrum in frequency–amplitude (f–A) coordinates can also be produced. The spectrogram of a given signal is calculated as follows [2]:

$$S(t, \omega) = |WFT(t, \omega)|^2, \quad (3)$$

where:

$WFT(t, \omega)$ – window function Fourier transform [3].

The use of the windowed Fourier transform when calculating a spectrogram makes it possible to improve the quality of the frequency spectrum calculation at the boundaries of the observation window.

The Welch method is a modification of the periodogram (2). It differs from the periodogram in that it divides the signal's time-domain vector into overlapping segments, multiplies each segment by a specific weighting function, and then calculates a modified periodogram (due to the application of the weighting function) for each segment before averaging them. The number of segments recommended for the Welch method should be a multiple of 2. Given the limitations of the fast Fourier transform, this number should not be too large, as this significantly reduces the resolution of the Welch method.

The use of weighting functions for signal segments in the Welch method makes it possible, compared with the periodogram method, to improve the quality of the frequency spectrum calculation by reducing spectrum smearing, whilst the use of overlapping signal segments reduces the variance of the estimation results.

The Thomson method (or Multitaper method) is used to calculate the spectrum of a signal using l modified (by means of weighting functions) periodograms $g_{l,n}$, each of which is obtained using different Slepian sequences:

$$S_k(f) = \Delta t \cdot \left| \sum_{k=0}^{N-1} g_{l,n} \cdot x_n \cdot e^{-j \cdot \omega \cdot k \cdot \Delta t} \right|^2, \quad (4)$$

where:

Δt – time interval between samples in a signal data set.

The Thomson method is free from some of the limitations of the discrete Fourier transform – in particular, it provides a more accurate determination of the relative phases for each frequency component of the signal under analysis.

Requirements for signal analysis methods to ensure reliable identification of dominant modes of low-frequency oscillations in real time

The results of the author's research [4, 5] make it possible to formulate the following requirements for signal analysis methods in terms of their suitability for use in determining the parameters of the dominant modes of low-frequency oscillations in real time:

1. The adequacy of identification and the accuracy of determining the parameters of the dominant modes of low-frequency oscillations due to the fact that the effective operation of damping devices depends on the accuracy of determining the dominant frequencies.

2. High frequency resolution due to the possibility of the existence in the power system or union of a combination of several vibration modes at closely spaced frequencies (for example, in Mexican power system with the frequencies of 0,32 Hz, 0,52 Hz, 0,62 Hz, 0,77 Hz and 0,92 Hz [6]).

3. The reliability of detecting low-frequency oscillations in a signal and determining the parameters of their dominant modes due to the need of identification of the dominant modes even with small amplitudes and to ensure resilience to noises (interferences) present in real signals.

4. High responsiveness, necessitated by the need to prevent oscillatory instability in the power system or power union arising from the onset and rapid development of low-frequency oscillations.

An important feature of the real-time mode for determining the parameters of low-frequency oscillation modes is the need to analyse samples of signal data, the set of which is periodically updated on a "first in – first out" basis.

The width of the observation window used during signal analysis with a particular method must be sufficient to yield adequate analysis results and, at the same time, must cover the shortest possible time interval, to ensure the necessary speed in identifying the dominant modes of low-frequency oscillations and assessing the presence of a threat to the operation of the power system or power union. In view of this, the number of signal samples within a given observation window and, accordingly, the duration (length) of the time interval covered by the observation window may vary both for different signal analysis methods and for different signal data samples corresponding to different operating modes of the power system or power union.

Results of testing non-parametric signal analysis methods with regard to application for the real-time detection of low-frequency oscillations

The testing of signal analysis methods was carried out using a synthesised three-component test signal with constant component amplitudes, described by the equation $y(t) = 100 + 2\sin(2\pi \cdot 0{,}1t) + 1\sin(2\pi \cdot 0{,}2t)$.

The test signal contains components with frequencies of 0,1 Hz and 0,2 Hz, which correspond to typical modes of low-frequency oscillations in power systems. To test signal analysis methods, a data set with a sampling rate of 50 Hz was used, with a time window covering the interval 0–10 s (a section of the test signal graphic is shown in Fig. 1). Testing signal analysis methods using a longer time window is not advisable, given the dynamics of changes in the amplitude of low-frequency oscillations when they occur in power systems or power pools.

The results of identifying the low-frequency components of the test signal using a periodogram, a spectrogram, and the Welch and Thomson methods, carried out on the basis of (2)–(4), are shown in Fig. 2.

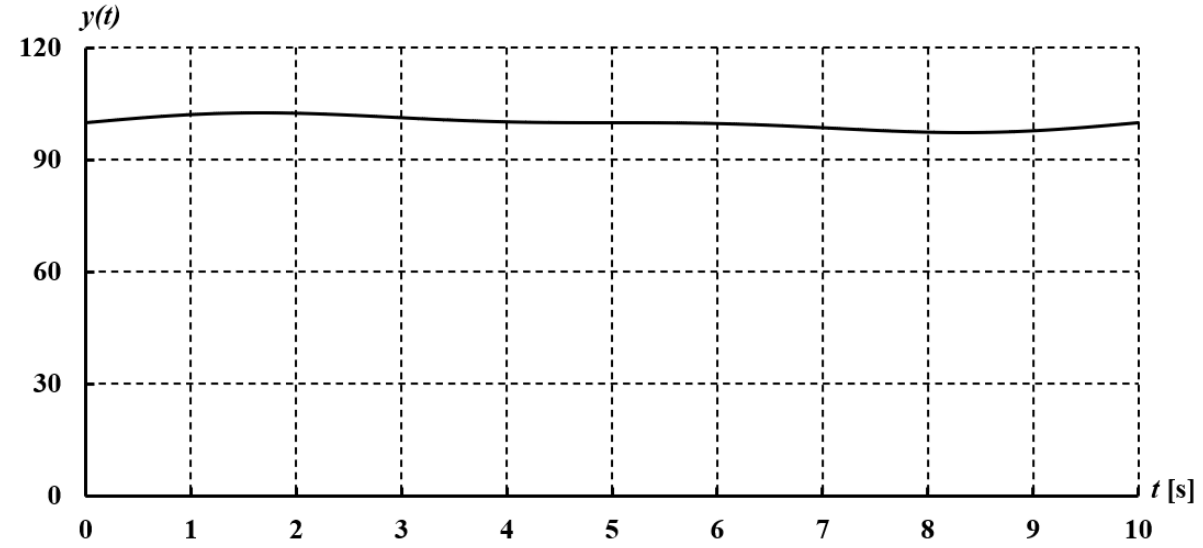

Figure 1. A section of the test signal graphic

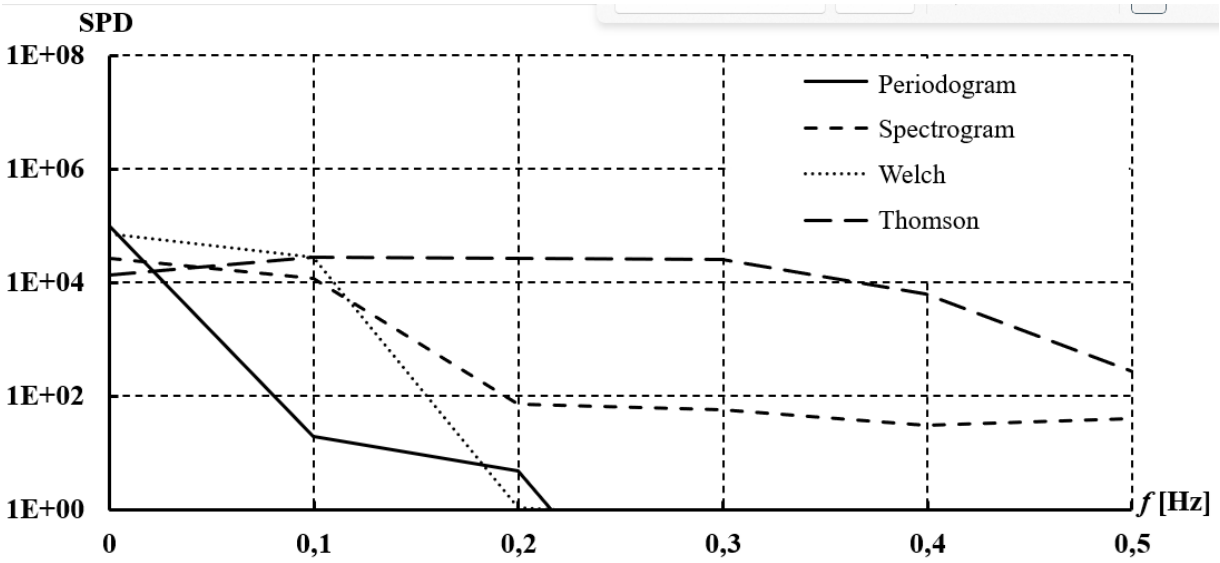

Figure 2. Results of the identification of low-frequency components of the test signal

During the calculations, no weighting functions (windows) were applied, which reduced the number of factors that could influence the results of the analysis. In order to calculate the SPD of the test signal data sample using a spectrogram and the Welch method, the data sample was divided into 8 segments with the maximum possible overlap between them to ensure the highest possible resolution of the tested signal analysis methods.

Conclusions

Analysis of the graphics in Fig. 2 showed that the non-parametric signal analysis methods under consideration were unable to identify components with frequencies of 0,1 Hz and 0,2 Hz in the 10-second test signal data set, which is due to the limitation imposed by the frequency resolution of the discrete Fourier transform, on which the methods under consideration are based.

Furthermore, the SPD plots obtained using the non-parametric signal analysis methods discussed do not correspond to the actual SPD plot of the test signal, as the sample of this signal does not contain any components with a frequency above 0,2 Hz.

Therefore, given the requirements for signal analysis methods, in view of their potential application for determining the parameters of low-frequency oscillations in the operating parameters of power systems and unions in real time, and taking into account the results of the study conducted, it can be concluded that the use of periodograms, spectrograms, and the Welch and Thomson methods for this purpose is not feasible.

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DETERMINING THE MAXIMUM LENGTH OF A FEEDER USING CRITERIA FOR PERMISSIBLE VOLTAGE DROP AND ACTIVE POWER LOSSES

Chyzhevskyi V.
Candidate of Technical Sciences,
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute",
Kyiv, Ukraine
DOI: 10.5281/zenodo.21095456

ABSTRACT

The selection of the cross-section of a wire or cable conductor during design calculations of feeder parameters for connecting a new consumer or a new source of electrical energy to an existing electrical network requires a number of operational constraints and technical and economic indicators to be taken into account. However, in many cases, this selection is made solely on the basis of the permissible current rating of the wire or cable conductor under steady-state operating conditions, as this approach makes it possible to minimise the calculations at the design stage. Whilst this simplification of the procedure for selecting the cross-section of a feeder wire or cable core is entirely acceptable in many cases, when a high-power consumer or source of electrical energy is connected to the feeder, this approach may lead to excessively high voltage drops and active power losses in the feeder.

This article examines an approach to selecting wire or cable conductor cross-sections based on tables that consider both the limitations on the feeder's permissible current and the limitations on the permissible voltage drop and permissible active power loss during the transmission of electrical energy along the feeder for various combinations of active load and power factor.

Keywords: feeder maximum length, voltage drop, active power losses.

Introduction

Electrical networks tend to expand continuously, which is caused by the commissioning of new power infrastructure facilities – power lines, transformer substations, and so on. This process is particularly intense in low-voltage electrical networks (up to 1 kV), which form the final stage in the conversion of electrical energy by voltage class and supply power to most consumers.

Connecting a new consumer or source of electrical energy with a high contracted or installed capacity to low-voltage electrical networks usually requires the construction of a new overhead or underground power transmission line to connect that consumer or source to the existing electrical network.

During the design phase of a power transmission line project its key design features are determined, in particular the cross-section of the conductor or cable core used. Proper selection of the conductor or cable core cross-section is a crucial task, as it affects:

- the acceptability of the power transmission line's operating parameters – in terms of the permissible current in the conductor or cable core;

- the admissibility of the operating parameters of the consumer's equipment – in terms of the permissible voltage at the end of the power transmission line;

- the economic operating indicators of the power transmission line.

Often, at the project design stage, the exact length of the feeder is not known for certain, as various route options may be under consideration – including the use of both overhead and underground power lines. Such uncertainty significantly complicates designers' tasks, as under these conditions it is not possible to verify whether the wire or cable of the designed feeder complies with the permissible voltage drop or permissible active power loss.

This problem can be effectively solved by referring to tables which can be used to determine the maximum permissible feeder length for various values of wire cross-section and cable core cross-section, active load and power factor, as well as for various permissible values of the voltage drop coefficient and active power losses in the feeder.

The problem of determining the maximum length of a feeder based on the permissible voltage drop

It is known that the Ohm's law for the low-voltage 3-phase feeder shown in Fig. 1 in conditions of symmetric load can be written as [1]:

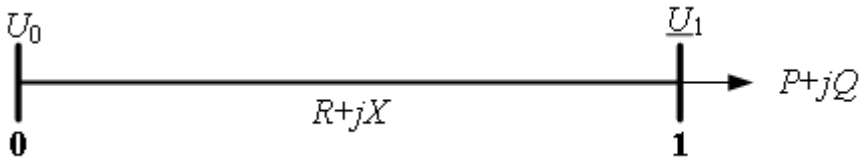

Figure 1 – Feeder of electrical network

$$U_0 = \underline{U}_1 + \underline{I} \cdot (R + jX) = (U_1' + jU_1'') + \left(\frac{P-jQ}{U_1'-jU_1''}\right) \cdot (r_0 + jx_0) \cdot L, \quad (1)$$

where:

U_0 – voltage at the beginning of the feeder (real number);

$\underline{U}_1$ – voltage at the end of the feeder (complex number);

U_1', U_1'' – active and reactive voltage components at the end of the feeder;

P, Q – consumer's active and reactive power;

$\underline{I}$ – feeder line current (complex number);

R, X – feeder resistance and reactance;

r_0, x_0 – feeder per length resistance and reactance;

L – length of the feeder.

After expansion (1) and grouping of the obtained expression in terms of r_0 and x_0 it can be rewritten in the real numbers as:

$$U_0 = U_1' + \left(\frac{(P\cdot U_1'+Q\cdot U_1'')\cdot r_0-(P\cdot U_1''-Q\cdot U_1')\cdot x_0}{U_1'^2+U_1''^2} + j\frac{(P\cdot U_1''-Q\cdot U_1')\cdot r_0+(P\cdot U_1'+Q\cdot U_1'')\cdot x_0}{U_1'^2+U_1''^2}\right)\cdot L. \quad (2)$$

Given that the maximum permissible value of the feeder voltage drop $\Delta U_{\max}$, %, is known, a system of equations can be derived from (2) to determine the maximum length of the feeder $L_{\max}$ based on the permissible voltage drop:

$$\begin{cases} U_0 = U_1' + \frac{(P\cdot U_1'+Q\cdot U_1'')\cdot r_0-(P\cdot U_1''-Q\cdot U_1')\cdot x_0}{U_1'^2+U_1''^2}\cdot L_{\max} \\ 0 = U_1'' + \frac{(P\cdot U_1''-Q\cdot U_1')\cdot r_0+(P\cdot U_1'+Q\cdot U_1'')\cdot x_0}{U_1'^2+U_1''^2}\cdot L_{\max} \\ U_1'^2 + U_1''^2 = \left((1-\Delta U_{\max})\cdot U_0\right)^2 \end{cases} \quad (3)$$

The system of equations (3) is consistent, as it contains 3 unknowns – U_1', U_1'' and $L_{\max}$.

The maximum permissible value of the feeder voltage drop $\Delta U_{\max}$ can be different for different electrical networks. For example, in Ukraine:

- for the 0,4 kV power transmission lines the maximum voltage drop is up to 6 %, excluding voltage drops in internal wiring [2];

- for the lighting systems that are powered directly from the general low-voltage electricity supply system permissible feeder voltage drop is 3% [3];

-for the other low-voltage installations that are powered directly from the general low-voltage electricity supply system permissible feeder voltage drop is 5% [3].

As the feeder's operating conditions must be within the current-carrying capacity of the wire or cable conductor, once the system solutions (3) have been obtained, the following condition must be verified:

$$\frac{P^2+Q^2}{3\cdot(U_1'^2+U_1''^2)} < I_{\max}^2, \quad (4)$$

where:

$I_{\max}$ – maximum permissible current of the wire or cable conductor.

Additional verification must be carried out to check the validity of the calculated values for the real component of the voltage at the end of the feeder U_1' and the maximum length of the feeder $L_{\max}$:

$$\begin{cases} U_1' > 0 \\ L_{\max} > 0 \end{cases} \quad (5)$$

Failure to satisfy conditions (4) and (5) will mean that it is impossible to transmit power $P+jQ$ to the end of the feeder with a specific resistance r_0+jx_0 at a voltage at the beginning of the feeder that equals to U_0 in conditions of providing feeder voltage drop less or equal to $\Delta U_{\max}$. A similar conclusion must be drawn if the system of equations (3) has no real roots or no roots at all.

The problem of determining the maximum length of a feeder based on the permissible active power losses

Given that the maximum permissible value of the active power losses across the feeder $\Delta P_{\max}$, %, is known, a system of equations can be derived from (2) to determine the maximum length of the feeder $L_{\max}$ based on the permissible active power losses:

$$\begin{cases} U_0 = U_1' + \frac{(P\cdot U_1'+Q\cdot U_1'')\cdot r_0-(P\cdot U_1''-Q\cdot U_1')\cdot x_0}{U_1'^2+U_1''^2}\cdot L_{\max} \\ 0 = U_1'' + \frac{(P\cdot U_1''-Q\cdot U_1')\cdot r_0+(P\cdot U_1'+Q\cdot U_1'')\cdot x_0}{U_1'^2+U_1''^2}\cdot L_{\max} \\ \frac{P^2+Q^2}{U_1'^2+U_1''^2}\cdot r_0\cdot L_{\max} = \Delta P_{\max}\cdot P \end{cases} \quad (6)$$

The system of equations (6) is consistent, as it contains three unknowns – U_1', U_1'' and $L_{\max}$.

As a rule, the maximum permissible value for the feeder active power losses is not specified in national regulatory documents, as the condition of low-voltage electricity networks and their load levels vary significantly between different distribution system operators operating within the same country. Instead, distribution system operators may set this limit themselves in their own regulatory documents.

The values obtained by solving system (6) must be checked to ensure they satisfy conditions (4) and (5). Failure to satisfy conditions (4) and (5) will mean that it is impossible to transmit power $P+jQ$ to the end of the feeder with a specific resistance r_0+jx_0 at a voltage at the beginning of the feeder that equals to U_0 in conditions of providing feeder active power losses less or equal to $\Delta P_{\max}$. A similar conclusion must be drawn if the system of equations (6) has no real roots or no roots at all.

Practical application of the research results

The results of applying systems of equations (3) and (6) to determine the maximum lengths of low-voltage feeders based on permissible voltage drop and permissible active power losses are illustrated using the example of a NAYY-type cable with aluminium conductors rated at 0,66 kV.

The specific resistance and specific reactance parameters for this cable, as well as the maximum permissible current for the cable conductor when laid underground, for phase conductor cross-sections ranging from 6 mm² to 240 mm², are given in Table 1.

Table 1.

Specifications for NAYY-type 0,66 kV cable

Parameter	Cross-section of a cable's phase conductor, mm^2											
	6	10	16	25	35	50	70	95	120	150	185	240
Specific resistance, Ohm/km	5,110	3,080	1,910	1,200	0,868	0,641	0,443	0,32	0,253	0,206	0,164	0,125
Specific reactance, Ohm/km	0,087	0,082	0,075	0,062	0,061	0,060	0,059	0,057	0,057	0,056	0,056	0,055
Permissible current, A	37	50	67	88	109	136	167	204	236	273	313	369

Table 2 shows the results of the calculation of the maximum feeder length, based on the permissible voltage drop and permissible active power loss, carried out using NAYY-type 0,66 kV cable, for the following conditions:

- source voltage – 400 V;
- load power factor – 0,95;
- permissible feeder voltage drop – 5%;
- permissible feeder active power losses – 3%.

Table 2.

Maximum feeder length, m, based on permissible feeder voltage drop of 5% and permissible feeder active power losses of 3% for NAVY-type 0,66 kV cable

P, kW	Criterion	Cross-section of a cable's phase conductor, mm^2											
		6	10	16	25	35	50	70	95	120	150	185	240
5	ΔU_{max}	295	488	784	1243	1709	2298	3284	4485	5592	6773	8333	10621
	ΔP_{max}	161	267	430	684	945	1279	1850	2559	3234	3968	4979	6521
10	ΔU_{max}	148	244	392	622	854	1149	1642	2243	2796	3386	4167	5311
	ΔP_{max}	80	133	215	342	473	640	925	1279	1617	1984	2489	3260
20	ΔU_{max}	74	122	196	311	427	574	821	1121	1398	1693	2083	2655
	ΔP_{max}	40	67	107	171	236	320	462	640	808	992	1245	1630
30	ΔU_{max}	–	81	131	207	285	383	547	748	932	1129	1389	1770
	ΔP_{max}	–	44	72	114	158	213	308	426	539	661	830	1087
40	ΔU_{max}	–	–	98	155	214	287	411	561	699	847	1042	1328
	ΔP_{max}	–	–	54	85	118	160	231	320	404	496	622	815
50	ΔU_{max}	–	–	–	124	171	230	328	449	559	677	833	1062
	ΔP_{max}	–	–	–	68	95	128	185	256	323	397	498	652
75	ΔU_{max}	–	–	–	–	–	153	219	299	373	452	556	708
	ΔP_{max}	–	–	–	–	–	85	123	171	216	265	332	435
100	ΔU_{max}	–	–	–	–	–	–	164	224	280	339	417	531
	ΔP_{max}	–	–	–	–	–	–	92	156	162	198	249	326
150	ΔU_{max}	–	–	–	–	–	–	–	–	–	226	278	354
	ΔP_{max}	–	–	–	–	–	–	–	–	–	132	166	217
200	ΔU_{max}	–	–	–	–	–	–	–	–	–	–	–	265
	ΔP_{max}	–	–	–	–	–	–	–	–	–	–	–	163

In Table 2 the symbol "–" indicates combinations of the cross-section of the feeder cable conductor or wire and the active load of the consumer connected at the end of the feeder for which conditions (4) or (5) were not met.

An analysis of Table 2 shows that, for a cable power transmission line, the criterion for determining the maximum feeder length based on permissible active power losses is more stringent than the criterion based on permissible voltage drop.

To facilitate the process of selecting the cross-section of a wire or cable conductor during the feeder design stage, tables may be drawn up for different types of wires and cables, different values of load power factors, and so on.

Conclusions

This paper proposes an approach to determining the maximum length of a low-voltage feeder based on permissible voltage drop and permissible active power losses, which is based on the use of tables compiled for various combinations of wire and cable types, active load power, load power factor, and so on.

The advantage of this approach is that it significantly simplifies the procedure for selecting the cross-section of a wire or cable conductor, particularly at the initial stages of design calculations, when the initial information required to carry out the calculations is incomplete.

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INFORMATION SYSTEM TO INCREASE THE EFFICIENCY OF DECISION-MAKING IN EMERGENCIES

Marchenko O.
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Senior Lecturer
https://orcid.org/0000-0001-5754-4920
Kornaga Ya.
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Doctor of Technical Sciences, Professor
https://orcid.org/0000-0001-9768-2615
DOI: 10.5281/zenodo.21095482

ABSTRACT

A study of natural environment emergency monitoring was conducted, in which it was shown that the implementation of effective management using network-centric principles in conditions of uncertainty requires the use of more advanced information systems.

Peculiarities of the use of information technologies in Ukraine in the situational centers of the mechanism for liquidation of emergency situations in the natural environment have been studied.

Keywords: natural environment emergency, conditions of uncertainty, data storage and management, information system.

Introduction

The rapid growth of information volumes in today's conditions and the limited time for decision-making by managers regarding the elimination of environmental emergencies leads to the problem of monitoring emergencies and making prompt decisions regarding their elimination. That is why for the heads of all environmental protection bodies it is critically important to have technological and methodological support that would facilitate high-quality analysis of information and prompt adoption of effective management decisions, especially in the event of environmental emergencies [1].

Problem Statement

The problem of increasing the effectiveness of management decisions still remains relevant and calls for further improvement of the mechanisms for making management decisions in emergency situations of the natural environment. The processes of comprehensive reform of various spheres of public life and the state administration system itself, as well as modern military-political realities in Ukraine, are very powerful factors in the frequent occurrence of crisis situations.

Development results

Among the main stages of making a management decision are: identification and diagnosis of the problem; preparation of the necessary information for the solution; generation of alternatives for solving the problem; determination of evaluation criteria; analysis of possible consequences of the proposed alternatives; adoption (selection) of the decision; its communication to the executors and organization of implementation; control of the results and the process of implementing the decision; evaluation of the results obtained [1-3].

The construction of the information system is proposed to be carried out on the basis of an ontological approach to the formation of a knowledge base of a subject-oriented area, which provides a systematic approach to the study of a subject-oriented area in conditions of uncertainty, which gives a holistic view of the subject-oriented area.

The developed scheme of the information system for increasing the efficiency of decision-making in the event of natural environmental emergencies consists of three levels: the level of data collection and preparation, the level of analysis and knowledge base, the level of simulation (Fig. 1).

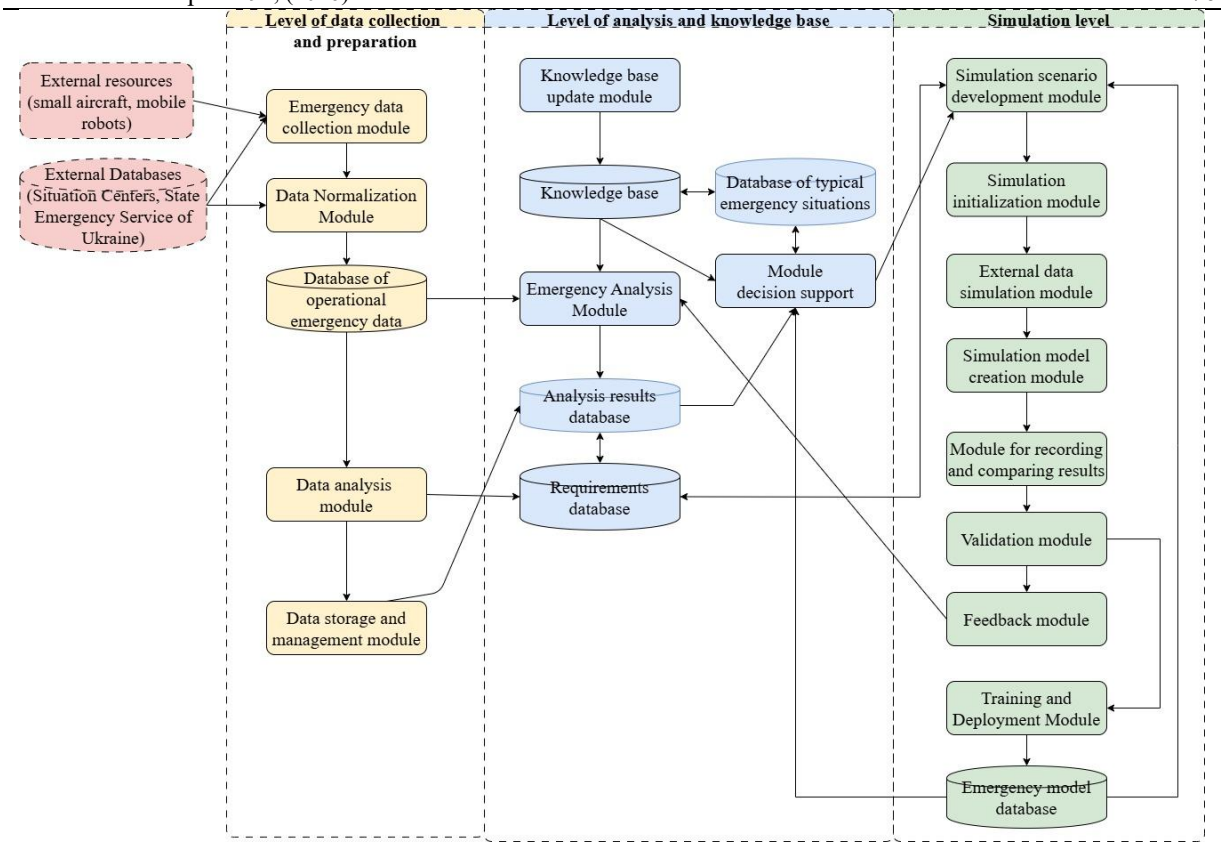
Level of data collection and preparation
Level of analysis and knowledge base
Simulation level
External resources (small aircraft, mobile robots)
External Databases (Situation Centers, State Emergency Service of Ukraine)
Emergency data collection module
Data Normalization Module
Database of operational emergency data
Data analysis module
Data storage and management module
Knowledge base update module
Knowledge base
Database of typical emergency situations
Emergency Analysis Module
Module decision support
Analysis results database
Requirements database
Simulation scenario development module
Simulation initialization module
External data simulation module
Simulation model creation module
Module for recording and comparing results
Validation module
Feedback module
Training and Deployment Module
Emergency model database

Figure 1 – Diagram of a decision-making information system

Description of the information system levels

The data collection and preparation level is responsible for integration with external data sources, data acquisition, and their preparation for analysis and storage. This level additionally houses the Emergency Operational Data Database (temporary storage of raw and normalized data).

The level includes modules:

– emergency data collection (data collection from external resources and systems: MLA, mobile robots, external databases of the SC, SES, possibly weather probes or other environmental monitoring systems involved);

– data normalization (cleaning, formatting and standardization of input data to specified formats acceptable for analysis);

– data analysis;

– data storage and management.

Analysis and knowledge base level. The central level where information is stored and processed. The level includes modules:

– knowledge base update (function for the administrator/expert to add new rules/scenarios to the knowledge base);

– emergency analysis (processing operational data using knowledge base rules, identifying threats/risks);

– decision support (forming recommendations and response plans based on the knowledge base and analysis).

At this level, the following are additionally placed: knowledge base (storage of emergency scenarios, rules, ontologies), analysis results database (storage of current emergency status, forecasts, risk assessments), requirements database (stores reference requirements and restrictions), database of typical (standard) emergencies (storage of historical data - plans and predicted models of emergency situations).

The simulation level is responsible for the execution and initial development of scenarios and the final evaluation to decide on deployment or the need for further development. This level additionally houses the database of emergency models.

The level includes the following modules:

– development of simulation scenarios (generation of emergency scenarios based on requirements coming from the requirements database);

– initialization of simulation (loading of created scenarios, corresponding to the emergency model);

– simulation of external data (simulation of dynamic input data flows over time);

– creation of a simulation model (processing of data created in the previous module and generation of forecasts);

– fixation and comparison of results (recording the output data of the simulation model, comparing the system forecast with the expected result - what should happen according to the scenario);

– validation module;

– feedback (generates a detailed report on the failure/non-compliance and sends it for revision);

– training and deployment (preparation of algorithms for deployment, creation of training and reference materials for personnel).

Additionally, several modules from different levels were detailed, which were selected as the most important in the processes of the information system.

1. Detailing of the data analysis module (Fig. 2).

The module receives data from the emergency operational data database. The data is transferred to the data verification module and the task preparation module. The requirements validation module checks the incoming data requirements and tasks for completeness, consistency and compliance with the standards in the requirements database, i.e. the readiness of the provided information to move to the next level of analysis.

In the future, if the requirements are not valid, they are transferred to the clarification request module, where the appropriate messages, error report, etc. are generated, and the emergency operational data database is accessed to obtain information on the clarification request. This cycle can be performed several times until the current emergency situation is maximally resolved. If the requirements are valid, they are transferred to the task formation module.

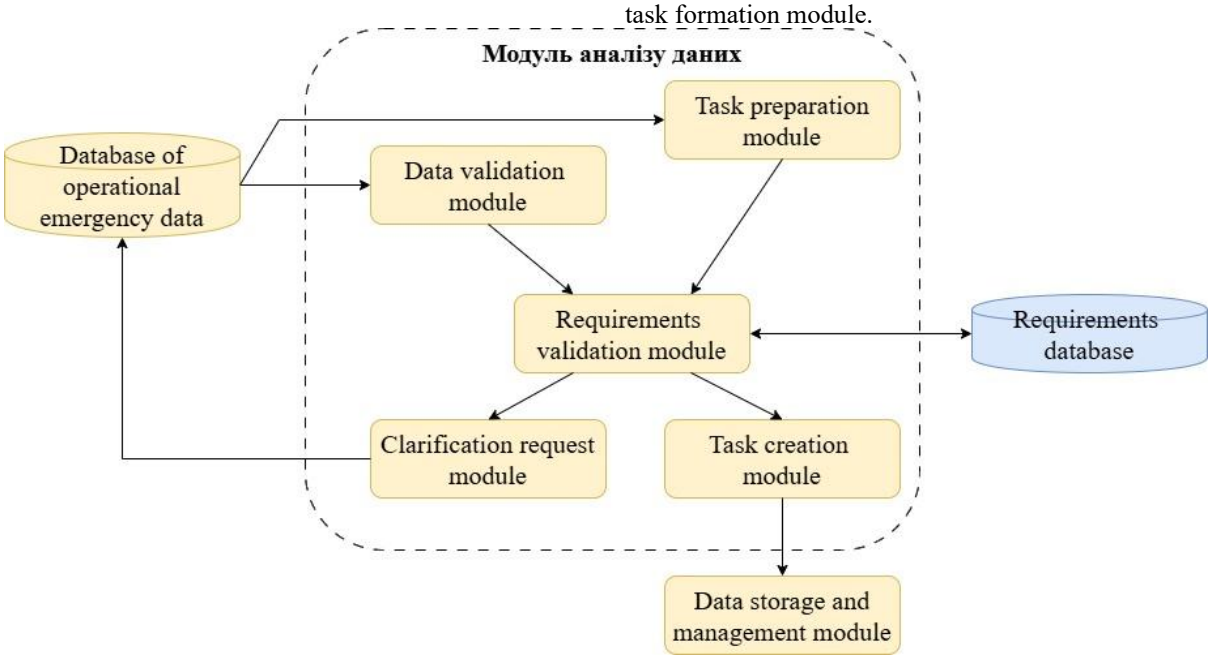

Figure 2 – Data analysis module

2. Detailing of the decision support module (Fig. 3).

The module is extremely important because it converts analytical data into actions - the formation of specific recommendations.

The decision support module receives input information from the analysis results database about the current status of the emergency situation, risk assessment. The response scenario identification module compares the input risks/statuses with typical data/rules from the knowledge base and from the database of typical emergency situations the relevant information for identifying the current situation - an important stage on which all further actions depend. According to the identification results, the information is transferred to the typical emergency plan generation module or to the task development module (for an atypical emergency situation). Technical means/resources are added to each task from those available at a certain time that should help in eliminating the emergency situation.

Prioritization module for mandatory implementation of task priorities for responding to events in an emergency situation in the plan.

The generated plans are transferred to the decision confirmation module for final approval by the decision maker.

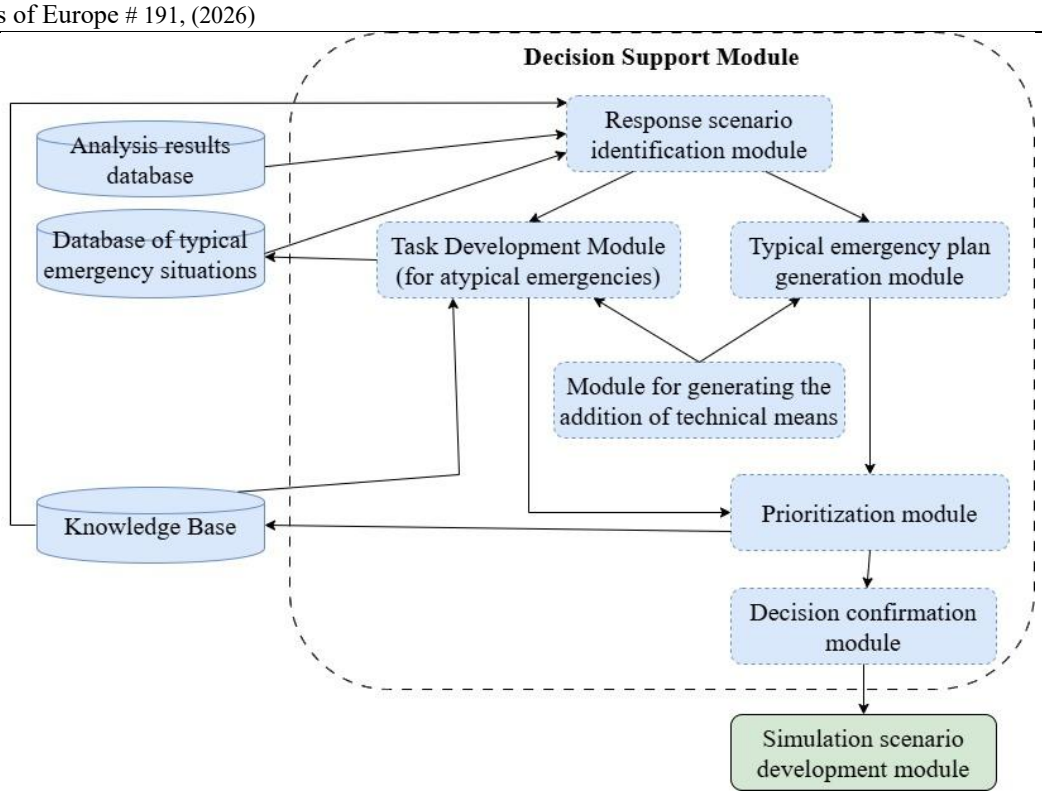
Decision Support Module
Response scenario identification module
Analysis results database
Database of typical emergency situations
Task Development Module (for atypical emergencies)
Typical emergency plan generation module
Module for generating the addition of technical means
Knowledge Base
Prioritization module
Decision confirmation module
Simulation scenario development module

Figure 3 – Decision support module

3. Detailing the simulation scenario development module (Fig. 4).

The simulation scenario development module creates a complete scenario that includes dynamic input data and a reference (expected) result and threat measurement models.

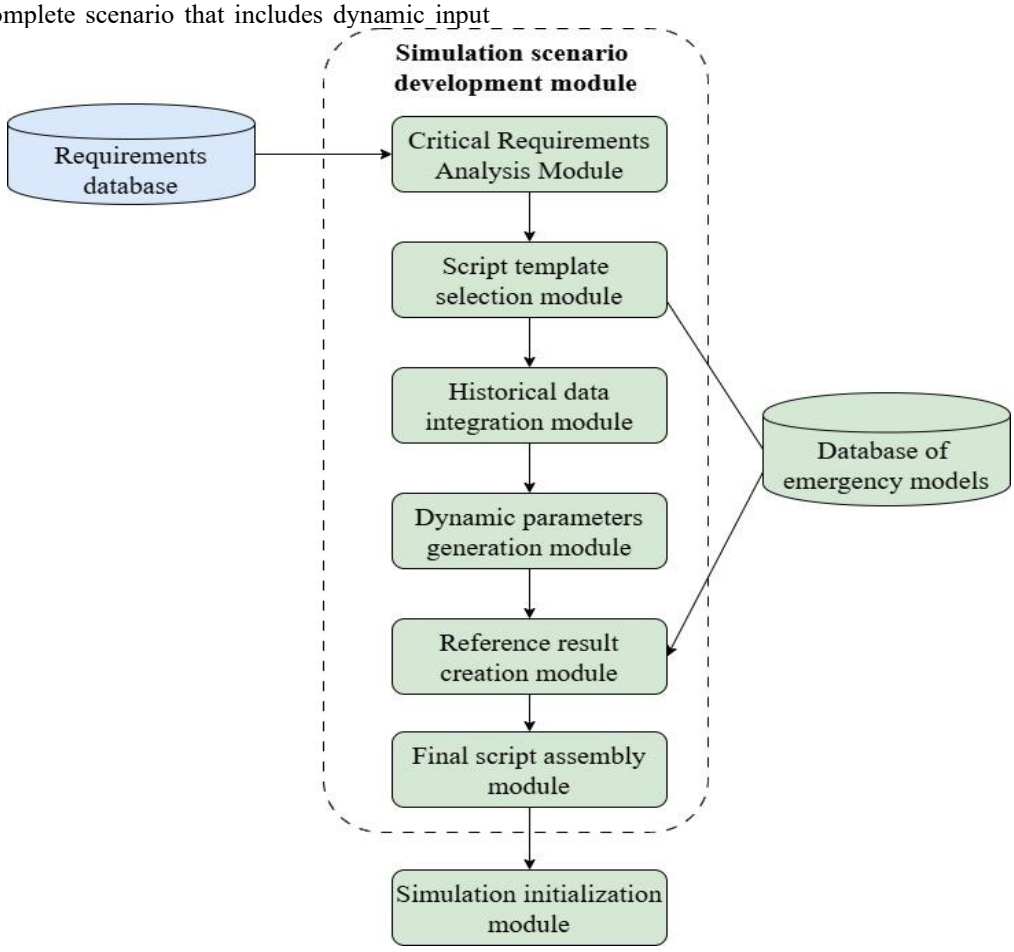

Figure 4 – Simulation scenario development module

The module receives data from the requirements database and the decision support module. The critical requirements analysis module tracks the requirements database for requirements that require special monitoring, based on this data, the scenario template selection module selects the appropriate scenario template based on the type of emergency using the emergency model database. The historical data integration module overlays historical/typical parameters on the selected scenario template. The dynamic parameter generation module develops dynamic data streams. The reference result creation module Using the integrated emergency model, calculates what the result should be for further comparison. The final scenario assembly module assembles the entire scenario using the dynamic data stream, reference result, and response time requirements.

Conclusion

An information system has been developed to increase the efficiency of decision-making in emergency situations, which allows for increased decision-making efficiency.

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No 191 (2026)

Sciences of Europe
(Praha, Czech Republic)

ISSN 3162-2364
The journal is registered and published in Czech Republic.
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Journal is published in Czech, English, Polish, Russian, Chinese, German and French, Ukrainian.
Articles are accepted each month.
Frequency: 24 issues per year.
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Editorial office: Křižíkova 384/101 Karlín, 186 00 Praha

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